Conifer Trials in Lesotho
A Review of Results

A.D. Leslie
Forestry Research Officer (TCO)

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Research Section
Forestry Division
Ministry of Agriculture
Lesotho

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ABSTRACT

The most adaptable conifer species in Lesotho is P. radiata, which will produce good yields and survival over a wide range of sites. Another pine that should be planted more widely is P. greggii which could be a useful species for inclusion in silvopastoral systems due to its light canopy.

Other pine species with potential on specific sites include P. patula and P. taeda. On very dry sites P. halepensis and P. brutia are recommended because of their high survival, but on other sites they should be avoided because of slow growth.

Of the other conifers, C. arizonica var. glabra has proved to be a tough but slow growing tree and is widely planted in the mountains. Other faster growing species must be found for the mountains. Trial blocks of P. densiflora, P. mugo and P. ponderosa should be established and growth compared with C. arizonica var. glabra. Other pines worth trying in the mountains would be P. attenuata, P. aristata and P. peuce.

Pines recommended but as yet not tested in the trials included; P. coulteri, P. engelmanii, P. lawsoniana, P. leiophylla, P. leptolepis, P. longifolia, P. mitis, P. teocote and P. wallichiana.

Also worth investigating are two cypresses, C. lusitanica and C. torrulosa over a range of sites. Other conifers recommended for testing were Callitris spp., Chamaecyparis lawsoniana, Juniperus virginiana and Pseudotsuga mensiezii.

ACKNOWLEDGEMENTS

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INTRODUCTION

A summary of the research work done to date was included as part of the Terms of Reference for the TCO Forestry Research Officer. Due to the amount of research completed it was decided to produce several reports rather than one large report to cover the work. This report summarises the work done by the Research Section of the Forestry Division (FD) and its predecesor, the Lesotho Woodlot Project (LWP) on conifer species and provenances.

Although conifers cover over half the area of Forest Reserves, recent FD policy has been to move away from the planting of trees unable to regenerate either by seed, suckers or coppice; such as the cypresses and most pines. This policy will reduce planting costs by avoiding the need to replant sites after the first rotation and is more suited to simple management, such as by villagers.

However, there will always be a need for conifers, particularly pines, on dry sites and if a small-scale sawmilling industry is established.

HISTORY OF CONIFERS IN LESOTHO

There are no conifers indigenous to Lesotho, however they have been a part of the landscape in Lesotho for over a century and a half. The first species to be introduced to Lesotho was believed to be Stone Pine (P. pinea), planted by French Missionaries at Morija in 1833 (Potter, undated).

By 1908, the following conifer species were described in Lesotho, by A.W. Heywood, (1908); Cedrus deodara, Chamaecyparis lawsoniana, Cupressus lusitanica, C. sempervirens and Pinus halepensis, P. pinaster and P. thunbergii. The most popular tree was recorded as being Pinus radiata.

A report by Miller, (1947) gave Deodar (Cedrus deodara) as being the best species, followed by P. radiata. Pinaster pine (P. pinaster) was recorded as regenerating naturally in Lesotho. Other species considered to have potential were Allepo pine (P. halepensis), Digger Pine (P. sabiniana) and Chir (P. longifolia).

By 1962 twelve species of pine and six of cypresses had been recorded (Poynton, 1966). Other conifers recorded in Lesotho at this time included Chamaecyparis lawsoniana, Cedrus deodara and Sequoiadendron gigantea (at Qacha´s Nek).

Introduction of new species increased markedly in the late 1970´s when a formal research component was formed within the LWP. The success of these new species and provenances is described.

THE TRIALS

Locations of each trial are shown on Map 1 and the seedlots tested in each trial in Tables 1 to 3.

1. Boqate Rock (1570m)

A simple trial (L/25/109) was established in 1978 on a ploughed site. Identity of the species tested is uncertain but one was thought to be P. greggii.

2. Bushman's Pass (2386m)

A block planting (L/25/89b) of C. glabra was established in 1981 to test the growth of this species under plantation conditions.

A randomised complete block experiment (L/25/89) was established at Bushman's Pass in 1982. This tested twenty seedlots of fourteen conifer species. Three and a half years later it was closed due to fire damage.

An unreplicated trial (L/25/89a) of seven seedlots of six pine species, including P. koraiensis was planted in late 1982. At less than three years old this trial was abandoned because it had been badly damaged by fire.

In late 1984 a randomised complete block land race and provenance trial (L/25/90FA) of C. glabra was established to test the field performance of sixteen seedlots. The site was ripped before planting and the trees fertilised.

3. Ha Foka (1780m)

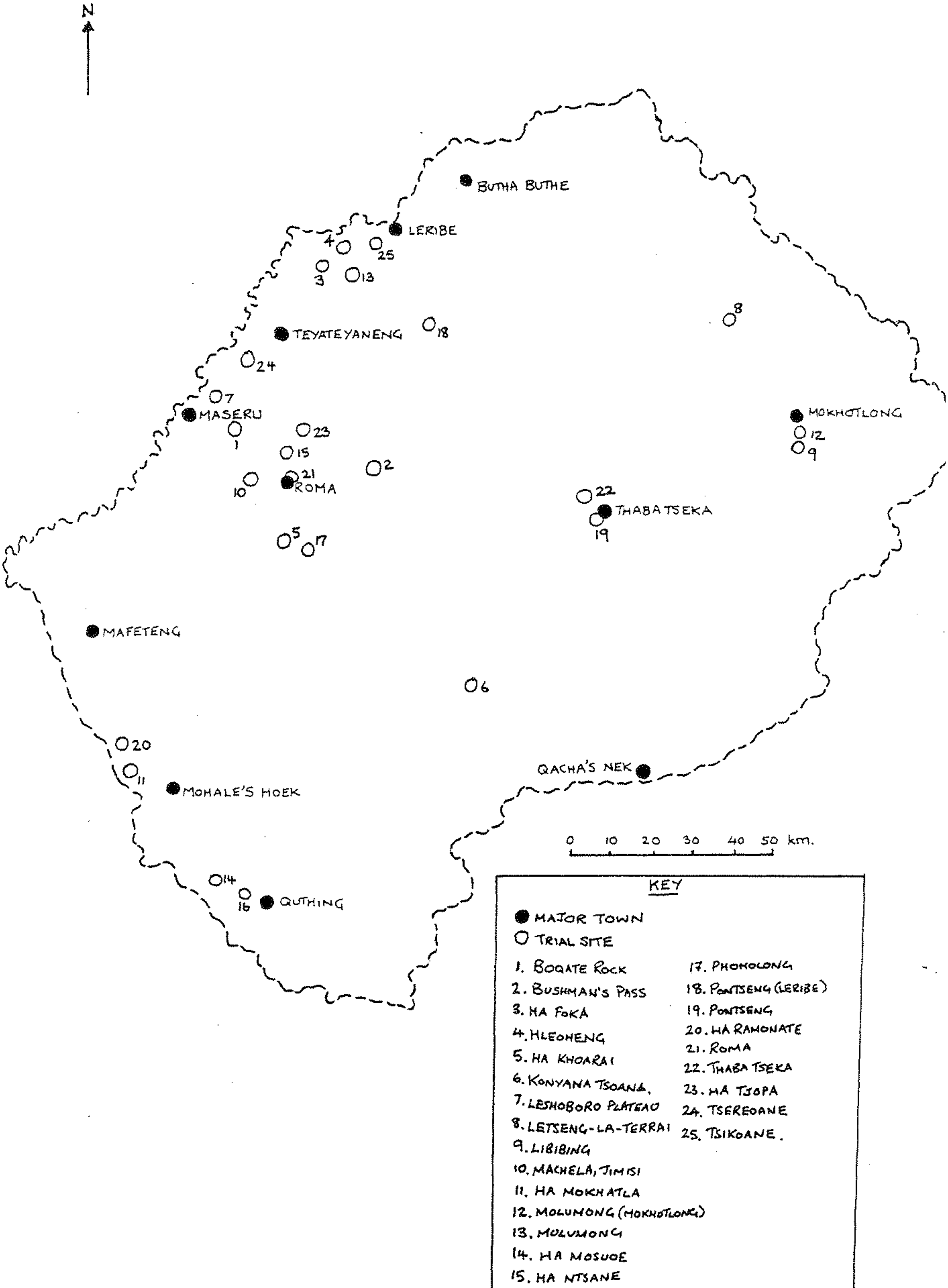
In 1981 a pine species trial was established (L/25/77). Single seedlots of seven species were tested in a randomised complete block experiment. The site was ripped and the trees deep planted and fertilised. Seedlots were raised in sleeves of three different sizes; 100ml, 215ml and 500ml. In the same year an unreplicated trial of a further six pine species was planted. Block plantings of three of the species in the main trial were also planted.

4. Hleoheng (1740m)

A trial (L/25/91) of randomised block design was established at Hleoheng in 1982. This tested twenty four seedlots of 14 pines and 2 cypresses. The site was ploughed and the trees fertilised.

5. Ha Khoarai (1840m)

In early 1988 a P. radiata provenance and land race trial (L/25/126A) was established, block I and II was pitted and block III ploughed.



MAP 1. LOCATION OF TRIAL SITES

Table 1 Conifer seedlots other than pines

Species	Seedlot Number	Trials
C. glabra	CGC1	87,88,89,104
C. glabra	CGL1	90FA,90FC
C. glabra	CGL2	90FA,90FC
C. glabra	CGL3	90FA,90FC,99
C. glabra	CGL4	90FA,90FC
C. glabra	CGL5	90FA,90FC
C. glabra	CGL7	90FA,90FC
C. glabra	CGL8	90FA,90FC
C. glabra	CGR2	90FA,90FC
C. glabra	CGC2	90FA,90FC
C. glabra	CGS1	90FA,90FC
C. glabra	CGN1	90FA,90FC
C. glabra	SETROPA1	90FA,90FC
C. glabra	ISRAEL1	90FA,90FC
C. glabra	SPAIN1	90FA,90FC
C. glabra	051-11	90FA,90FC
C. glabra	CGR1	90FC
C. glabra	?	103
Seq. giganteum	RVP1	99
C. libani	CLL1	99
C. glabra	CG82/1	107
C. glabra	30524	76,80a,87,88,89,91,104,107
C. glabra	?	101
C. horizontalis	CSHC1	80a,87,88,89,91,104
C. horizontalis*	26997	76,87,88,89,91,104
C. brevifolia	?	31

*later identified as C. glabra

Table 2 Pine Seedlots other than Pinus radiata

Species	Seedlot	Trials
P.brutia	PBC1	78b,80a,87,88,89,89a,91,98,104,107
P. brutia	594	78b,80a,87,88,89,89a,91,98,104,107
P. brutia	?	77
P. contorta	108-09	89a
P. densiflora	PDK1	89a,91,99,107,131
P. echinata	110-33	78b,80a,87,88,89,104
P. edulis	PP-NM-79	101,102
P. eldarica	PE-77-PK	77,78,78b,80,82,87,88,89,91,96,98,101,1
P. elliottii	28693	78b,80a,87,88,89,91
P. greggii	PGG1	78b,80a,87,88,89,91,96,98,104,107
P. halepensis	29278	82,98
P. halepensis	PHG1	78b,87,88,91,98
P. halepensis	28278	77,78,80,87,88,89,91,98,108
P. halepensis	PHJ1	98a
P. jeffreyi	1	78c,80a,88
P. jeffreyi	No.7	101,102
P. jeffreyi	2-37412	131,126c
P. koraiensis	PTK1	91,131
P. lambertiana	No.9	102
P. maximinoi	30/77	78c,80a,87,88,91
P. michoacana		98a
P. montezumae	30598	78b,80a,87,88,89,91,96,98,104
P. mugo	156	89a,99,107
P. muricata	PMC1	78b,80a,87,88,89,91,98,104
P. muricata	R1004	76,78,80,87,88,89,91,98,104,108
P. nigra	404	78b,88,89,89a,91,104
P. nigra	1942	99,107
P. nigra	PNC3	99
P. patula	?	77,82
P. patula	29810	78,80,87,88,89,91,98,101,102,104
P. patula	R1008	80a,87,88,89,91,104
P. pinaster	28558	76,78,80a,88
P. pinea	26479	77,78
P. pinea	30634	98
P. ponderosa	?	76,78,101
P. ponderosa	?	80
P. ponderosa	PP-78-COC	88
P. ponderosa	P085/030	131
P. ponderosa	OR943-1	131
P. ponderosa	OR863-1	131
P. ponderosa	0-142	131,126c
P. ponderosa	NM180	131,126c
P. ponderosa	?	102
P. ponderosa	No.2	105, 106
P. pseudostrobus	8/76	78c
P. pseudostrobus	R1003	76,78,80
P. pseudostrobus	4/76	86
P. pseudostrobus	8/76	86
P. pseudostrobus	30/77	86
P. roxburghii	123	77,78
P. roxburghii		78,80,82
P. roxburghii	060	120
P. roxburghii	0120	120
P. roxburghii	0141	120
P. roxburghii	1002	120
P. roxburghii	1203	120
P. roxburghii	2002	120
P. roxburghii	3002	120
P. roxburghii	5001	120
P. roxburghii	6001	120
P. sabiniana	26484	76
P. sabiniana		80a,88

CONTINUED....

Table 2 continued

Species	Seedlot	Trials
P. sabiniana	No.8	101,102
P. strobiformis	PS-78-COC	78c,80a,88,101,102
P. strobiformis	No.1	101,102
P. taeda	28442	78b,80a,87,88,89,91
P. thunberghii	PTK1	78b,80a,87,88,89,91,104,107
P. virginiana	132-07	78b,80a,87,88,91,104

Table 3

Pinus radiata Seedlots

Origin	Seedlot	Number	Trials
RSA	?		77,80
?		26209	78b,87,88,89,91,104,86
ex California, CSIRO	?		78,82
?		30647	87,88,89,91,104
ex Lesotho	?		91
Bela-Bela, Lesotho	PR83/1		115FA,115FB,115FC
Mopeli	PR83/2		115FA,115FB,115FC
Thota Peli	PR83/3		115FA,115FB,115FC
Tale	PR83/4		115FA,115FB,115FC
Morija	PR83/5		115FA,115FB,115FC
LAC	PR83/6		115FA,115FB,115FC
RSA Improved		25142	115FA,115FB,115FC
Cape, RSA		32886	115FA,115FB,115FC
Cape, RSA		32843	115FA,115FB,115FC
Lesotho	87/1		131
California, USA		25918	131
California, USA		12585	126A,126B,126C
California, USA		12586	126A,126B,126C
California, USA		12587	126A,126B,126C
California, USA		12588	126A,126B,126C
California, USA		12589	126A,126B,126C
California, USA		12590	126A,126B,126C
ex Plenty, Lesotho	Px6001		126A,126B,126C
California, USA	124-01		126A,126B
ex Plenty, Lesotho	5-47086		126A,126B,126C
?		25181	126A,126B,126C
California, USA		12597	126A,126B,126C
California, USA		12596	126A,126B,126C
California, USA		12595	126A,126B,126C
California, USA		12594	126A,126B,126C
California, USA		12593	126A,126B,126C
California, USA		12592	126A,126B,126C
California, USA		12591	126A,126B,126C
California, USA		12403	126A,126B,126C
California, USA		25155	126A,126B,126C
RSA, Seed Orchard	1/0/77/13/3		126A,126B,126C
Wanaku Forest, NZ	2/1/84/51/2		126A,126B,126C
Kaingoroa Forest, NZ	2/2/84/67/3		126A,126B,126C
Kaingoroa Forest, NZ	3/3/82/2/3		126A,126B,126C
Kaingoroa Forest, NZ	7/1/77/01/3		126A,126B,126C
Rankelburn Forest, NZ	6/1/79/027/2		126A,126B,126C
RSA, Seed Orchard		25160	126A,126B,126C
Lesotho	PR8713		126A
Lesotho	PR871		126A,126B,126C
?		29925	102,101

6. Konyana Tsoana, Semonkong (2265m)

A complete randomised block trial (L/25/131) of seven conifer species and *Fraxinus pennsylvanica* was planted on a pitted site.

7. Leshoboro Plateau (1800m)

In 1976 a block planting (L/25/108) of a single species of pine, *P. muricata* was planted in mixture with eucalypts.

In early 1982 a replicated trial (L/25/86) of three provenances of *P. pseudostrobus* was established at Leshoboro.

Bulk plantings of three pine species (L/25/96); *P. eldarica*, *P. greggii* and *P. montezumae* were also planted in early 1982.

In early 1984 a *P. radiata* land race and provenance trial (L/25/115FB) was established on a ploughed site to test nine seedlots. Design was a randomised complete block.

8. Letseng-la-Terrai (3050m)

Three trials (L/25/31, L/25/32 and L/25/33) were planted in pits at the diamond mine at Letseng-la-Terrai in 1979. Conifer species comprised *C. deodara*, *C. brevifolia*, *P. contorta*, *P. mugo*, *P. ponderosa* and *P. rigida*. In addition three eucalypt species and broom were planted.

Later, in April 1990 a few *Salix fragilis* were planted in mixture with a few *P. ponderosa* and one *Leucosidea sericea*. In 1991 *P. radiata* and several hardwoods were also planted.

9. Libibing, Mokhotlong (2420m)

In 1983 a simple trial (L/25/107) of eleven seedlots of eight conifer species was established.

A land race and provenance trial (L/25/90FC) of *C. glabra* was established in 1984 at Libibing, near Mokhotlong. Design was a randomised complete block. The trees were deep planted in 35cm x 35cm pits.

10. Machela, Jimisi (1560m)

Two blocks of two pine species, one possibly *P. sabiniana* (L/25/113) were planted in early 1977.

11. Ha Mokhatla (1500m)

In early 1989 twenty four seedlots of *P. radiata*, two seedlots of *P. ponderosa* and one seedlot of *P. jeffreyi* were tested in a randomised complete block experiment (L/25/126C).

12. Molumong, Mokhotlong (2140m)

Seven pine species and *C. glabra* were planted in April 1983 on a pitted site (L/25/99). A variety of other species were used to beat-up the trial in 1984, including *Cedrus libani* and *Sequoiadendron giganteum*.

13. Molumong (1770m)

Twenty seven seedlots of *P. radiata* were tested in a randomised complete block trial planted in early 1988.

14. Ha Mosoue (1500m)

In early 1982 a complete randomised block trial (L/25/87) of twenty four seedlots of seventeen conifer species was planted. The site was pitted and the plants fertilised at planting.

15. Ha Ntsane (1890m)

A *P. radiata* land race and provenance trial (L/25/115C) was established on a ploughed site in 1984. The design was a randomised complete block.

16. Paballong (1600m)

An unreplicated trial (L/25/88) of thirty conifer seedlots was established in 1982. These covered twenty pine species and two species of cypress. Trees were deep planted in pits of unspecified size and the trial was fertilised at planting. The trial was closed at four years old and results should only be viewed as being preliminary.

17. Phomolong (1980m)

Two trials were established on this site in 1980, a replicated pine species trial (L/25/76) and an unreplicated trial (L/25/76a) of conifer species. The pine species trial tested one seedlot of *P. eldarica*, *P. halepensis*, *P. patula* and two seedlots of *P. radiata*. The conifer trial was established to compare single seedlots of five pines; *P. ponderosa*, *P. pinaster*, *P. pseudostrobus*, *P. muricata* and *P. sabiniana* and two cypresses; *C. arizonica* var *glabra* and *C. sempervirens* var *horizontalis*. The site is on a gentle east slope and was ploughed before planting.

18. Pontseng, Leribe (1900m)

In 1981 an unreplicated trial (L/25/80) of single seedlots of seven species of pine was established. A further unreplicated (L/25/80a) trial of twenty four conifer seedlots was established in 1982.

19. Pontseng (2270m)

A replicated trial (L/25/102) was established in 1981 testing nine pine species and one cypress species.

20. Ha Ramonate (1570m)

A replicated trial of five pine species (L/25/78), small block plantings of three species and a side planting of three pine species (L/25/78a) were established on a gentle north easterly facing site in 1981. The trial tested single seedlots of *P. halepensis*, *P. eldarica*, *P. pinea*, *P. roxburghii* and *P. patula*. Two of these were planted in small blocks, *P. roxburghii*, *P. eldarica* and one species not tested in the trials; *P. radiata*. Small plots of *P. ponderosa*, *P. muricata* and *P. pinaster* were established as side plantings.

In 1982 a replicated trial testing eighteen seedlots of fifteen conifer species was planted (L/25/78b). The pines comprised *P. brutia*, *P. echinata*, *P. eldarica*, *P. elliottii*, *P. greggii*, *P. halepensis*, *P. montezumae*, *P. muricata*, *P. nigra*, *P. radiata*, *P. taeda*, *P. thunbergii* and *P. virginiana*.

Also in 1982 further unreplicated plots (L/25/78c) were established of three pine species, two seedlots of *P. pseudostrobus*, one seedlot of *P. strobiformis* and one of *P. jeffreyi*.

21. Roma (1600m)

Plots within the Roma woodlots were assessed (L/25/114), including two pines, *P. radiata* and *P. roxburghii*.

22. Thaba Tseka (2150 - 2370m)

In 1981 two conifer trials were established, one at 2370m the other at 2300m by Blair Orr of the Thaba Tseka Project. The species tested were *C. arizonica* var. *glabra*, *P. edulis*, *P. eldarica*, *P. jeffreyi*, *P. lambertina*, *P. patula*, *P. ponderosa* var. *scopulorum*, *P. radiata*, *P. strobiformis*.

In 1979 two unreplicated trials of four pines (L/25/105) and of three pines (L/25/106), intimately mixed were planted at the Basotho Pony Project.

In 1981 a replicated conifer species and provenance trial (L/25/101) was established at the Graziers Association Site. Nine pine and one cypress species were tested.

A randomised complete block trial (L/25/104) of 20 conifer species or provenances was planted in 1982.

23. Ha Tjopa (1800m)

An unreplicated trial (L/25/82) of five pine species was planted in early 1981.

24. Tsereoane (1600m)

In 1983 a P. roxburghii provenance trial was planted (L/25/120). Nine seedlots were tested in a simple, unreplicated experiment.

In early 1984 a P. radiata land race and provenance trial (L/25/115FA) was planted. This tested nine seedlots in a complete randomised block design experiment.

25. Tsikoane

Bulk plots of eleven seedlots in early 1982 of eight pine species were planted (L/25/98) in an unreplicated trial.

In 1983 bulk plots (L/25/98a) of four promising species, two pines and two non-conifer casuarinas were established.

THE SEEDLOTS

Information on the seedlots tested is shown in Tables 4-6 and the seedlots in each trial are shown in Tables 1-3. Due to poor records the origin of many seedlots was not avalailable.

ANALYSIS

Within trials the performance of the seedlots was assessed by using a Yield Function unless only heights of seedlots were measured in the field. When this occurred height (in metres) times survival (as a proportion) was used. The Yield Function combined dbh, height and survival thus:

Yield Function = dbh^2 X height X survival/ 1000

Where dbh is in centimetres, height in metres and survival as a percentage. This gives a rough relative volume for the seedlots in each trial.

Survival in many of the replicated trials was poor and only eight have had anaysis by Analysis of Variance (ANOVAR), applied to the results. Plot means were used in the ANOVAR. Furthermore where survival was low and many whole plots had complete mortality an ANOVAR was not attempted. With such plots variance within the treatment (seedlot) would be great and it would be improbable that an ANOVAR would show significant differences.

Where most survivals in the trial fell outside the range 20 to 80 percent an ArcSine transformation was applied to the survivals, as recommended in Mead and Curnow,(1983), before the ANOVAR was conducted.

Table 4 Origins of conifer seedlots other than pines

Species	Seedlot	Locality	Lat		Long		Altitude	Soil
C. glabra	CGC1	Cyprus	35	?	34	?	?	?
C. glabra	CGL1	Mokhotlong, Lesotho	29	18	29	4	2160	Basalt
C. glabra	CGL2	Below Prison, Maseru	27	30	29	18	1500	Duplex
C. glabra	CGL3	Thaba Tseka	29	33	28	36	2300	Basalt
C. glabra	CGL4	Likaleneng, Maseru	29	27	28	3	2200	Basalt
C. glabra	CGL5	Molimo Nthuse	29	25	27	54	2000	Basalt
C. glabra	CGL7	Khanyane Woodlot	28	52	28	7	1600	
C. glabra	CGL8	Alwynskop Woodlot	30	23	27	37	1600	
C. glabra	CGR2	Ladybrand, OFS, RSA	29	11	27	26	1500	Duplex
C. glabra	CGC2	Cyprus	?	?	?	?	?	?
C. glabra	CGS1	Sweida, Syria	33		37		1500	
C. glabra	CGN1	Mayfield, New Zealand	?		?		?	
C. glabra	SETROPA1	Italy	?		?		?	
C. glabra	ISRAEL1	Mas'ada, Golan	33	15	35	40	900	Limestone
C. glabra	SPAIN1	Vallodolid, Spain	41		5		1500-3000	
C. glabra	051-11	Gila Cnty, Arizona, USA	34		111		?	
C. glabra	CGR1	Tweespruit, OFS, RSA	?	?	?	?	1600	
Seq. giganteum	RVP1	California, USA	?	?	?	?	?	?
C. libani	CLL1	Beyrouth, North Lebanon	?	?	?	?	1800	?
C. glabra	CG82/1	Thaba Tseka, Lesotho	29	33	28	36	2300	Basalt
C. glabra	30524	Ottesdal, Tvl, RSA	26	48	26	0	1490	Red Loam
C. glabra	?	ex Arizona	?	?	?	?	?	
C. horizontalis	CSHC1	Cyprus	?	?	?	?	?	?
C. horizontalis*	26997	Middleberg, Cape, RSA	31	29	25	1	1270	?

*later identified as C. glabra

Table 5 Origins of Pine Seedlots other than Pinus radiata

Species	Origin	Seedlot	Lat	Long	Altitude	Soil
P.brutia	Cyprus	PBC1	35 ?	34 ?	?	?
P. brutia	Sogutdagi, Isparta, Turkey	594	27 21	30 54	575	?
P. brutia	Cyprus	?	? ?	? ?	?	?
P. contorta	El Dorado, California	108-09	38 8	120 0	2134	?
P. densiflora	Yong Dock Cty, Korea	PDK1	36 30	129 24	50	clay loam
P. echinata	Cherokee, Texas, USA	110-33	31 8	95 3	138	?
P. edulis	New Mexico, USA	PP-NM-79	? ?	? ?	2120	?
P. eldarica	Quetta Valley, Pakistan	PE-77-PK	? ?	? ?	760	?
P. elliottii	(supplied by RSA Forest Dept)	28693	? ?	? ?	?	?
P. greggii	(supplied by RSA Forest Dept)	PGG1	? ?	? ?	?	?
P. halepensis	Alexandria, E Cape, RSA	29278	33 42	26 22	196	sand
P. halepensis	Greece	PHG1	? ?	? ?	?	?
P. halepensis	RSA	28278	? ?	? ?	?	?
P. halepensis	Jerash, Jordan	PHJ1	? ?	? ?	900	?
P. jeffreyi	California, USA	1	? ?	? ?	?	?
P. jeffreyi	?	No.7	? ?	? ?	?	?
P. jeffreyi	?	2-37412	? ?	? ?	?	?
P. koraiensis	Ko Yang Cty, Korea	PKK1	37 46	127 9	270	sandy clay loa
P. lambertiana	Washington, USA	No.9	? ?	? ?	?	?
P. maximinoi*	Dipilto, Nicaragua	30/77	13 43	86 30	1100	sand
P. michoacana	Lancers Gap, Lesotho	?	29 18	27 30	1600	sand
P. montezumae	Belfast, E Tvl, RSA	30598	25 40	30 1	1888	sandy loam
P. mugo	Graubunden, Switzerland	156	? ?	? ?	?	?
P. muricata	USA	PMC1	? ?	? ?	?	?
P. muricata	New Zealand	R1004	? ?	? ?	?	?
P. nigra	Aktuzla, Turkey	404	39 21	28 34	1300	sandy clay
P. nigra	Andirin, Turkey	1942	37 44	36 21	1500	?
P. nigra	Cyprus	PNC3	? ?	? ?	?	?
P. patula	RSA	?	? ?	? ?	?	?
P. patula	Jessievale, Tvl, RSA	29810	29 14	30 31	1733	?
P. patula	Molimo Nthuse, Lesotho	R1008	? ?	? ?	?	?
P. pinaster	Leiria, Portugal	28558	39 45	8 51	?	?
P. pinea	Cedarberg, Cape, RSA	28479	32 21	19 5	830	?
P. pinea	?	30634	? ?	? ?	?	?
P. ponderosa	ex Black Hills	?	? ?	? ?	?	?
P. ponderosa	ex Dorado	?	? ?	? ?	?	?
P. ponderosa	Coconino, Arizona	PP-78-COC	? ?	? ?	>500	?
P. ponderosa	?	P085/030	? ?	? ?	?	?
P. ponderosa	?	OR943-1	? ?	? ?	?	?
P. ponderosa	?	OR863-1	? ?	? ?	?	?
P. ponderosa	?	O-142	? ?	? ?	?	?
P. ponderosa	?	NM180	? ?	? ?	?	?
P. ponderosa	?	?	? ?	? ?	?	?
P. ponderosa	?	No.2	? ?	? ?	?	?
P. pseudostrobus	?	8/76	? ?	? ?	?	?
P. pseudostrobus	Maseru, Lesotho	R1003	29 18	27 30	1500	?
P. pseudostrobus	?	4/76	? ?	? ?	?	?
P. pseudostrobus	?	8/76	? ?	? ?	?	?
P. pseudostrobus	?	30/77	? ?	? ?	?	?
P. roxburghii	RSA	123	? ?	? ?	?	?
P. roxburghii	RSA	?	? ?	? ?	?	?
P. roxburghii	Dhading, Nepal	060	27 52	85 4	750	?
P. roxburghii	Kailali, Nepal	0120	28 57	80 38	1240	?
P. roxburghii	Darduijla, Nepal	0141	29 45	80 22	1210	?
P. roxburghii	Panduthar, Nepal	1002	? ?	? ?	?	?
**P. roxburghii	Kailali, Nepal	1203	? ?	? ?	?	?
P. roxburghii	Sakhuwasabha, Nepal	2002	? ?	? ?	?	?
P. roxburghii	Dankhuta, Nepal	3002	? ?	? ?	?	?
P. roxburghii	Lamidara, Nepal	5001	? ?	? ?	?	?
***P. roxburghii	Dhading, Nepal	6001	? ?	? ?	?	?
P. sabiniana	Cedarberg, RSA	26484	? ?	? ?	500	Shallow sand
P. sabiniana	N. Italy	?	? ?	? ?	?	?

CONTINUED.....

Species	Origin	Seedlot	Lat		Long		Altitude	Soil	
P. sabiniana	USA	No.8	?	?	?	?	?	?	
P. strobiformis	Locket Meadows, Arizona, USA	PS-78-COC						8750	
P. strobiformis	USA	No.1	?	?	?	?	?	?	
P. taeda	Hlabisa, N. Natal	28442	28	23	32	19		60	
P. thunbergii	Eui Chang, Korea	PTK1	35	9	128	40		50	sandy loam
P. virginiana	Tenessee, Cherokee, USA	132-07	35	?	82	?	?	?	

*P. pseudostrobus var tenuifolia
**same seedlot as 120
***same seedlot as 060

Table 6 Origin of P. radiata seedlots

Seedlot	locality	lat		long		Altitude	Soil
?	RSA	?	?	?	?	?	?
26209	RSA	?	?	?	?	?	?
?	California ex CSIRO	?	?	?	?	?	?
30647	Nuweberg, Caledon, Cape, RSA	34	5	19	3	792	loam
?	ex Lesotho	?	?	?	?	?	
PR83/1	Bela-Bela, Lesotho	29	2	28	1	1700	duplex?
PR83/2	Mopeli	28	47	28	18	1770	duplex transition
PR83/3	Thota Peli	29	8	27	52	1660	duplex
PR83/4	Taie	28	49	28	11	1700	duplex
PR83/5	Morija	29	37	27	28	1600	duplex
PR83/6	LAC	29	18	27	31	1500	duplex
25142	RSA Improved	?	?	?	?	?	?
32886	Cape, RSA	?	?	?	?	?	?
32843	Cape, RSA	?	?	?	?	?	?
87/1	Maseru & Roma, Lesotho			Various			
25918	California, USA	?	?	?	?	?	?
12585	California, USA	?	?	?	?	?	?
12586	California, USA	?	?	?	?	?	?
12587	California, USA	?	?	?	?	?	?
12588	California, USA	?	?	?	?	?	?
12589	California, USA	?	?	?	?	?	?
12590	California, USA	?	?	?	?	?	?
Px6001	ex Plenty, Lesotho	?	?	?	?	?	?
124-01	California, USA	?	?	?	?	?	?
5-47086	ex Plenty, Lesotho	?	?	?	?	?	?
25181	?	?	?	?	?	?	?
12597	California, USA	?	?	?	?	?	?
12596	California, USA	?	?	?	?	?	?
12595	California, USA	?	?	?	?	?	?
12594	California, USA	?	?	?	?	?	?
12593	California, USA	?	?	?	?	?	?
12592	California, USA	?	?	?	?	?	?
12591	California, USA	?	?	?	?	?	?
12403	California, USA	?	?	?	?	?	?
25155	California, USA	?	?	?	?	?	?
1/0/77/13/3	RSA, Seed Orchard	?	?	?	?	?	?
2/1/84/51/2	Wanaku Forest, NZ	?	?	?	?	?	?
2/2/84/67/3	Kaingoroa Forest, NZ	?	?	?	?	?	?
3/3/82/2/3	Kaingoroa Forest, NZ	?	?	?	?	?	?
7/1/77/01/3	Kaingoroa Forest, NZ	?	?	?	?	?	?
6/1/79/027/2	Rankelburn Forest, NZ	?	?	?	?	?	?
25160	RSA, Seed Orchard	?	?	?	?	?	?
PR8713	Lesotho	?	?	?	?	?	?
PR871	Lesotho	?	?	?	?	?	?
29925	RSA	?	?	?	?	?	?

For some others the calculation of the means of height, dbh and survival and the Yield Function or height x survival was the only analysis undertaken. For the trial at Konyana Tsoana height increment x survival was used. This was because of the slow annual growth at this site and the relatively large differences in height at planting.

The results of trials with generally poor survival have not been analysed, although the results of some are mentioned in the discussion. Also early trials (L/25/105, L25/106, L/25/109, L/25/113) were not analysed. The identity of the species tested is uncertain and records for them are poor.

The type of analysis undertaken for each trial is described in Table 7.

RESULTS

A summary of results of the trials that were analysed are shown in Appendix 1-6.

DISCUSSION

Failure of Trials

Many of the conifer trials have poor survival, often due to a number of factors unrelated to climate and edaphic conditions; including poor nursery practice, handling, planting, browsing, fire, vandalism and rodent damage. Unfortunately the exact cause of death of many of the trees has not been recorded, which makes it difficult to make recommendations, especially for those seedlots with few survivors but good growth and only represented in a few trials.

An investigation was made of the planting dates of some trials with poor survival, which was not explained in experiemental notes. Rainfall data were obtained from the Meteorological Department and compared with planting date. Wettest year betweeen 1979 and 1990 was found to be 1988, while the driest was 1980 (Table 8). Mean annual rainfall (Figure 1), it was decided, was not of sufficient detail to assess whether a year could be described as a drought year.

FIGURE 1

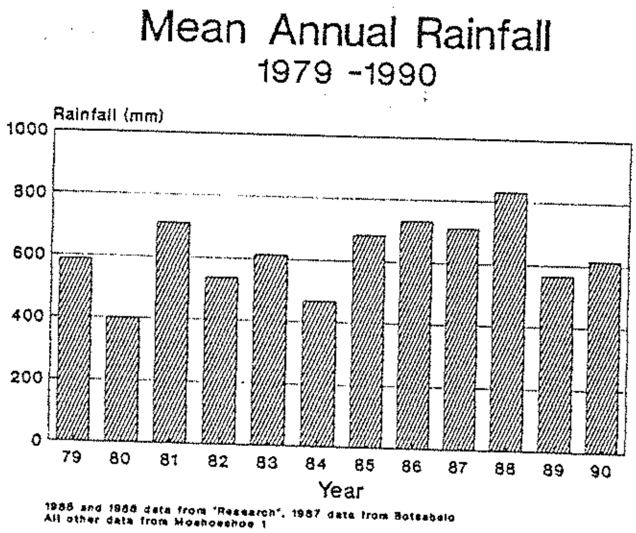


Table 7 Type of Analysis for each Trial

Trial Code	Description	Type	Analysis	Notes
L/25/31	Letseng Mine Mixed plantings	Unreplicated	Simple comparison	Highest trial in Lesoth
L/25/32	Letseng Mine Mixed plantings	Unreplicated	Simple comparison	Highest trial in Lesoth
L/25/33	Letseng Mine Mixed plantings	Unreplicated	Simple comparison	Highest trial in Lesoth
L/25/76	Phomolong Pines	Replicated	YF	Poor Survival
L/25/77	Ha Foka Pines	Replicated	YF & ANOVAR	
L/25/77a	Ha Foka Blocks	Unreplicated	YF	
L/25/78	Ha Ramonate Pines	Replicated	YF & ANOVAR	
L/25/78b	Ha Ramonate Conifers	Replicated	YF	
L/25/78c	Ha Ramonate Conifers	Unreplicated	None	Very Poor Survival
L/25/80	Pontseng Conifers	Unreplicated	YF	
L/25/80a	Pontseng Conifers	Unreplicated	YF	
L/25/82	Ha Tjopa Pines	Unreplicated	Simple comparison	Very early results
L/25/86	Leshoboro P. pseudostrobus	Replicated	None	Very poor Survival
L/25/87	Ha Mosuoe Conifers	Replicated	YF	Poor Survival
L/25/87a	Ha Mosuoe Conifers	Unreplicated	YF	
L/25/88	Paballong	Unreplicated	YF	
L/25/89	Bushman's Pass Conifers	Replicated	None	Burned very early
L/25/89a	Bushman's Pass Conifers	Unreplicated	None	Burned very early
L/25/90FA	Bushman's Pass C. glabra	Replicated	None	Closed very early
L/25/90FB	Thaba Tseka C. glabra	Replicated	None	Not planted?
L/25/90FC	Libibing C. glabra	Replicated	YF & ANOVAR	
L/25/91	Hlecheng Conifers	Replicated	ANOVAR	
L/25/96	Leshoboro Bulk Plots	Unreplicated	YF	
L/25/98	Tsikoane Bulk Plots	Unreplicated	YF	
L/25/98a	Tsikoane Bulk Plots	Unreplicated	YF	
L/25/99	Molumong, Mokhotlong	Replicated	None	Very few survivors
L/25/101	Grazers Association, Thaba Tseka	Replicated	None	Very poor survival & gro
L/25/102	Pontseng Conifers	Unreplicated	Ht x Svl	
L/25/103	LYS Conifers	Unreplicated	None	
L/25/104	Thaba Tseka Conifers	Replicated	Ht x Svl	Closed early as site re
L/25/105	Pony Project	Unreplicated	None	Uncertain identity of sp
L/25/106	Pony Project	Unreplicated	None	Uncertain identity of sp
L/25/107	Bulk Plot of C. glabra	Unreplicated	None	????
L/25/108	Bulk Plot P. muricata	Unreplicated	None	????
L/25/109	Mixed Pines at Bogate Rock	Unreplicated	None	Uncertain identity of sp
L/25/113	Machela pines	Unreplicated	None	Uncertain identity of sp
L/25/114	Roma Plots	Unreplicated	None	No age data
L/25/115FA	Tsereoane P. radiata	Replicated	YF & ANOVAR	
L/25/115FB	Leshoboro P. radiata	Replicated	YF & ANOVAR	
L/25/115FC	Ha Ntsane P. radiata	Replicated	YF & ANOVAR	
L/25/120	Tseroane P. roxburghii	Replicated	None	Very poor survival
L/25/124	Semonkong	-	None	Never Planted
L/25/125	Semonkong	-	None	Never planted
L/25/126A	Ha Khoarai P. radiata	Replicated	YF & ANOVAR	
L/25/126B	Molumong P. radiata	Replicated	YF & ANOVAR	
L/25/126C	Ha Mokhatla P. radiata	Replicated	YF & ANOVAR	
L/25/131	Konyana Tsoana Conifers	Replicated	YF	Early results

Table 8 Mean Monthly Rainfall Data, 1979 - 1990

Month	Year											
	79	80	81	82	83	84	85	86	87	88	89	90
J	82.60	50.10	191.90	34.20	46.20	76.30	97.00	57.20	35.50	35.80	57.90	167.60
F	119.70	62.50	121.80	80.90	36.10	27.40	59.00	69.00	111.80	144.10	153.80	78.40
M	12.90	61.50	95.70	27.70	38.90	60.50	62.80	100.40	70.50	157.20	79.80	153.20
A	64.20	18.00	47.00	120.70	51.40	15.30	36.40	23.20	96.60	121.70	52.10	80.70
M	27.80	5.30	20.90	7.90	20.40	84.90	6.80	0.00	1.60	24.70	60.90	2.80
J	21.80	0.00	21.70	13.70	29.00	0.40	0.00	41.80	0.00	21.20	24.40	31.60
J	53.90	0.00	0.00	21.80	53.00	2.00	0.00	0.00	120.00	0.90	3.10	2.80
A	41.20	4.10	41.20	0.00	0.00	49.00	0.00	77.80	45.70	13.10	7.60	23.80
S	20.60	83.50	3.50	27.50	21.70	5.80	7.00	28.20	161.40	44.40	2.70	0.50
O	85.40	5.40	48.90	101.60	97.40	68.30	121.00	160.20	35.90	145.40	22.50	6.50
N	63.30	146.80	67.60	103.20	149.40	104.60	146.40	207.20	131.00	46.40	77.90	14.50
D	57.00	51.00	94.30	25.10	92.20	27.50	154.20	72.20	108.00	133.50	33.40	77.50
Total	588.60	400.60	709.80	536.80	614.00	467.20	683.60	731.20	710.90	830.90	565.80	615.60
Month Avg	49.05	33.38	59.15	44.73	51.17	38.93	56.97	60.93	59.24	69.24	47.15	51.30

1985 and 1986 data from Maseru Research, 1987 data from Botsabelo
Other data from Moshoeshoe 1 Airport

For example in 1990 mean annual rainfall was 615.6mm, however only 21.5mm fell during the normally wet months of September to November, which follow the long dry winter. Many trees died during those months. The mean monthly rainfall for 1980 and 1988 was plotted to examine the distribution of rainfall through the year (Figure 2). Planting dates of the trials is shown in Table 9.

FIGURE 2

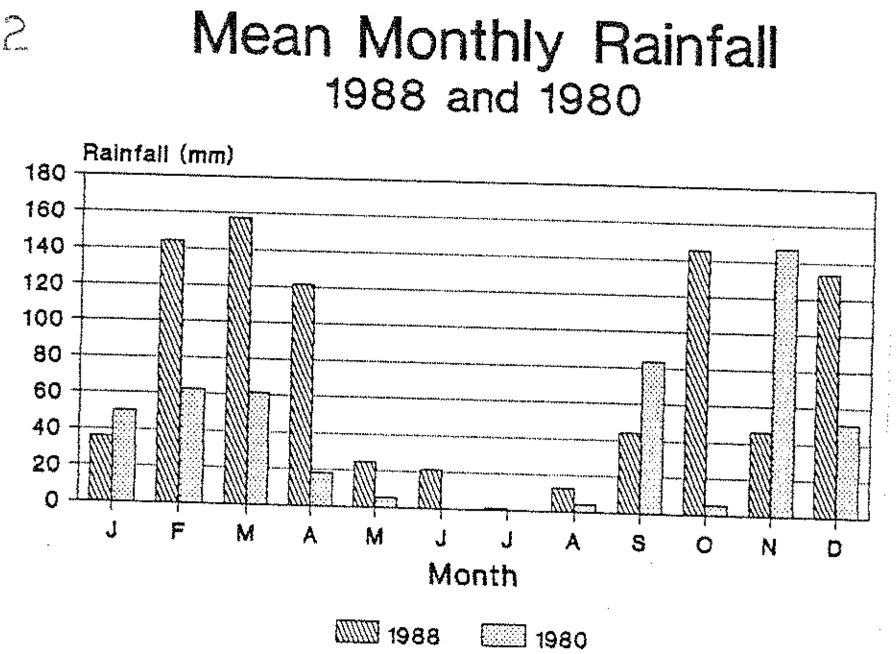


Table 9 Dates of Planting of Selected Trials with Poor Survival

Name	Number	Date Planted
Phomolong Pines	L/25/76	Feb 1981
Ha Ramonate Conifers	L/25/78c	Feb 1982
Ha Mosuoe Conifers	L/25/87	Feb 1982
Molumong, Mokhotlong Conifers	L/25/99	Sept 1983
Grazers' Association, Thaba Tseka	L/25/101	Apr 1981
Tsereoane <u>Pinus roxburghii</u>	L/25/120	Oct 1983
Ha Foka	L/25/77	Mar 1981
Pontseng (Leribe)	L/25/102	Apr 1981
Pontseng	L/25/80a	Jan 1982
Thaba Tseka Conifers	L/25/104	Apr 1982

Several trials it appears may have failed because of the lack of rains soon after planting, especially those planted between March and October. Failure of trials such as L/25/76, L/25/80a, L/25/99 and L/25/120 would not apperar to be linked to poor rainfall. In 1982 there was a dry period during March which might account for the failure of L/25/78c and L/25/87. The other trials were planted at the start of the dry season and probably did not have sufficient time to establish themselves on the site and build up sufficient reserves to survive the dry winter months.

Performance of Conifer Species in Lesotho

Pines

P. brutia

This species is a very close relative of P. halepensis and in some classifications has subspecies status. Unsurprisingly this species, like P. halepensis has shown best performance, relative to other species on dry sites such as Paballong, near Quthing. On better sites, such as at Pontseng (Leribe) this species has very poor growth compared with many other species. Seedlots of this species have shown similar performance to P. halepensis.

A seedlot from Jordan both survived and grew particularly poorly and this seedlot should be avoided.

P. canariensis

Endemic to the Canary Islands, this pine is unusual in its to produce shoots from a cut stump. It produces a particularly durable, dense and strong wood (Poynton, 1979). At Ha Ramonate, survival of this species in a block planting was 100%. However the growth rate was disappointing. Not recommended because of its poor growth.

P. contorta

A very variable species with a wide distribution in western north America and is found from sea level to 3350m altitude. Three varieties have been identified (Farjon, 1984). At the high altitude trial at Bushman's Pass this species had failed completely 18 months after planting. It is likely however that rat damage contributed to this total mortality. At the extreme mountain site of Letseng Mine all trees had died twelve years after planting, but it is probable that browsing by livestock was a factor. It has been tried by PLENTY Project Nursery at Ha Makoae and also in the FD Research Nursery, where it grew very slowly and has not been planted in any of the woodlots. Results to date are poor, however only one seedlot from El Dorado, California has been formally tested. Worth further testing with careful selection of provenance to cover the three varieties.

P. densiflora

Found in Japan, Korea and China; in Japan it grows from sea level to 2300m (Farjon, 1984). Survival was relatively good at two trials at Mohotlong. However at Bushman's Pass survival was only 28% eighteen months after establishment, although damage by fire and a high rat population were undoubtedly factors. It may be that this species could provide an alternative to *C. arizonica* var *glabra* in the mountains, although Poynton, (1979) describes it as slow growing. To date only a low altitude seedlot from Korea has been tested and so a wider range of seedlots should be tested.

P. echinata

A pine with a very wide distribution in the south-eastern USA spanning more than 1 100 000 km^2 (Poynton, 1979) it grows from sea level up to 750m in the Appalachian Mountains. In Lesotho this species showed poor growth and survival at Pontseng (Leribe) and Paballong. As this species was represented by one seedlot from a low altitude area in Texas, it should not be dismissed as a potential species.

P. edulis

This species had only average performance at Pontseng and very slow growth at Thaba Tseka, being one third of that of *P. radiata* and survival was good but not as good as *P. radiata*.

P. eldarica

This species is a close relative of *P. brutia* and *P. halepensis*. Preliminary results from Paballong were encouraging, although much poorer performance than *P. halepensis* and *P. brutia* on this dry site. Unfortunately, there was disappointing survival and growth of older trees in trials at Ha Foka and the high altitude Pontseng trial. In bulk plantings at Tsikoane its performance was much worse than *P. greggii*, but better than the other six species. Growth of this species at the high altitude Pontseng trial was only average and survival very poor. On all types of sites there are other species which will grow and survive better.

P. elliottii

A native to the south eastern USA and although recommended by Phillips, (1973) for the foothills, it showed pathetic survival and poor growth at Ramonate and Pontseng but reasonable growth at Hleoheng with 60% survival. Poynton, (1979) believes it has potential in South Africa, as although slower growing than *P. radiata* it is relatively free of pests and is tolerant of a wide range of soils. Farjon, (1984) describes it as a fast growing species. Inconclusive results from trials in Lesotho.

P. greggii

A close relative of *P. patula* this species has potential as a fuelwood and timber species on lowland sites with higher precipitation and on foothill sites. Planting should be avoided on mountain and dry lowland sites. It has a very open canopy, with light branching in plantation conditions. The low level of shade this tree produces would make it suitable for inclusion into silvopastoral systems. In its natural habitat it produces a rather weak, brittle wood. Plantation grown material is similar to the wood of P. patula, although less strong, stiff and tough (Poynton, 1979). Poynton, (1979) believes it has potential as a timber tree for South Africa.

At Hleoheng in the north it has performed particularly well showing only slightly inferior growth to P. radiata and P. taeda. At Pontseng, another trial in the north, P. greggii was the best performing species, however, P. radiata was not represented in this trial. Results at two and a half years, from Paballong, a drier site show P. brutia and P. halepensis to have only marginally better performance. Although survival of these species was up to four times greater than that of P. greggii, their early growth was relatively very poor. Later results at eight and a half years old, from Ha Mosuoe another trial in the dry southern lowlands show that survival of P. brutia and P. halepensis is approximately twice that of P. greggii but growth is still much poorer.

P. halepensis

This species has proved to be able to have exceptional survival even on particularly dry sites, although growth is unimpressive. There are major differences in growth and survival between seedlots. The Jordanian (PHJ1) and Cyprus (PHC1) seedlots should be avoided.

This species should only be considered for fuel production on the driest sites because of its poor growth rate. The wood is well suited for making fence posts, as it is readily impregnated with preservatives. From tests in South Africa (Poynton, 1979), it has some potential for sawn timber.

On very dry sites, such as Ha Mosuoe, this species, and P. brutia survive much better than P. radiata or P. greggii, although growth of these species is considerably better. Later results at Ha Mosuoe mirror these results, although P. radiata was not tested. On higher rainfall sites there are species with equal survival and considerably better growth.

P. jeffreyi

A tree of the Sierra Nevada in California it is found at altitudes from 1000m to 3000m (Farjon, 1984). In Lesotho this species has shown poor performance and survival. After eight years two surviving trees at Ha Ramonate had only grown an average of 0.4m tall. At Paballong, two and a half years after planting and the high altitude trial at Pontseng, few trees survived and growth was very poor. This is surprising as Poynton, (1979) notes that it will survive in greater extremes of climate than the closely related P. ponderosa. From trial results it should not be considered for planting in Lesotho.

P. *koraiensis*

Naturally occuring in Japan, Korea, Siberia and China. Found up to altitudes of 2500m in Japan (Farjon, 1984). It has had very limited testing in Belfast Plantation, South Africa, where its growth was found to be slow (Poynton, 1979). At eighteen months this species showed no survival at the high altitude Bushman's Pass trial. However this is an extreme site and with much grazing by livestock, damage by rats and fires. Also only a relatively low altitude provenance from Korea was tested. Other seedlots should be tested.

P. *lambertiniana*

A tree of central western USA, it is confined to relatively moist western slopes in the mountains. It is found as high as 2400m altitude in the Sierra Nevada (Farjon, 1984).

In Lesotho only one seedlot was tested. At the high altitude Pontseng trial, the only seedlot of this species failed completely. At the Grazer's Association site at Thaba Tseka, seven months after planting over half the trees of this species had survived. However height growth was very poor compared with P. *radiata* and C. *glabra*. Due to only one seedlot being tested and only very early results being available this species cannot be dismissed. Further testing required, possibly of Californian rather than Washington provenances.

P. *maximinoi*

This species has now been relegated to variety status, being known as P. *pseudostrobus* var *tenuifolia*. It is described as such in some of the trials. At Pontseng (Leribe) a high foothill site this variety failed completely. At Hleoheng it showed uninspiring growth and survival. Survival at Ha Mosuoe was less than 10% and height growth about two thirds that of P. *radiata*, whilst at Paballong in Quthing District no trees had survived two and a half years after planting. This variety is not suitable for planting in Lesotho.

P. *michoacana*

A close relative of P. *montezumae* with a more southerly distribution (Farjon, 1984). In Lesotho this species was tested at Tsikoane. Unfortunately only an assessment at four and a half months exists and percentage survival cannot be calculated because the number planted was not noted.

P. *montezumae*

A pine of the subtropical highlands of Mexico and of the tropical border area with Guatemala. The "species" has been used as a basis of a complex of closely related species. Most of these are not frost resistant, although some reach altitudes of 4000m (Farjon, 1984). The timber has been found to be unsuitable for construction, but is of sufficient quality for joinery (Poynton, 1979). A further use could be as a garden ornmantal as it is very atractive with its dark green, long needles. Noted in Poynton, (1979) as being moderately fast growing.

Reasonable performance at Ramonate, vastly inferior to P. radiata though. Two small block plantings at Leshoboro and Tsikoane Plateaux show good survival and healthy trees. At Pontseng a higher rainfall site on basalt soils this species had done well, with good survival and reasonable growth, but was still inferior to P. greggii. It was also bettered by P. greggii in bulk plantings at Leshoboro Plateau. Although well adapted to the lowlands and foothills of Lesotho, there are species that will grow considerably faster.

P. monticola

Widely distributed in western USA, it is found from sea level in Washington to 3300m in California. It has only had very limited testing in Lesotho; at a block planting Ha Foka this species failed with no survivors. Insufficient seedlots and trials to reach any conclusions.

P. mugo

A shrub or small tree found in the Alps and Carpathians, reasching an altitude of 2300m (Farjon, 1984). In Lesotho eighteen months after planting at Bushman's Pass this species showed both pathetic growth and survival; but the trial had been subjected to heavy browsing, burning and damage by rats. At Letseng Mine, the highest trial in Lesotho this species has survived for 12 years, with limited protection from browsing. Growth during this period was less about one and a half metres. Possible uses might include rehabilitation of mountain slopes and as the outer, lower layer in multi-row shelterbelts.

P. muricata

A rare tree with a scattered distribution on the shore and islands of the Californian coast (Farjon, 1984). In Lesotho unimpressive growth and survival at Pontseng and complete failure at Ha Ramonate. On a lowland plateau site at Tsikoane, in the higher rainfall north of the country, performance was average, but far worse than the best species, P. greggii. This generally poor performance is surprising as this is a close relative of P. radiata. However only two seedlots of this species were tested and in New Zealand much variation has been noted within the species (Wilcox, 1983). A "blue form" with better growth rate and form is distinguished from the poorer "green form". Certainly at present this species should not be planted in Lesotho, but testing of seedlots of the "blue form" sourced from New Zealand or from natural population in the Mendocino County in the USA would be worthwhile.

P. nigra

A pine of the Mediterranean region and the shores of the Black Sea (Poynton, 1979). In Lesotho at Hlecheng, Ramonate Pontseng and Paballong this species had not survived. At Bushman's Pass, eighteen months after planting, survival was only 10% and growth poor, while at Thaba Tseka survival was only 5% after 12.5 months. No further work should be undertaken on this species in the mountains of Lesotho.

P. *patula*

A tree of high rainfall areas in the warm to temperate highlands of Mexico. It is found from altitudes of 1500m to 3000m (Farjon, 1984). In Lesotho this species grows particularly well on sites which receive high rainfall and can tolerate the cold of the high foothills. At Setibing woodlot, near Bushman's Pass there is a fine young stand of *P. patula*, the adjacent *C. glabra* being about a half to a third the height. At the trial at Bushman's Pass one seedlot (29810) of this species showed the greatest height growth at age 27 months. Another seedlot showed poor growth (R1008). Height growth of the better seedlot was double that of *P. radiata*. At the high altitude Pontseng trial height growth of one seedlot (29810) was only half that of *C. glabra* and survival only 20%.

In the dry conditions of the southern lowlands this species survives badly. At Paballong and Ha Ramonate growth of *P. patula* was good but survival pathetic.

Survival of two seedlots of this species was surprisingly poor at Hlecheng, a fairly high rainfall site. Growth was good however. At Tsikoane, another plateau site in the north its near relative *P. greggii* showed better survival and much better growth.At Ha Foka the few survivors grew very well. Possibly they had been planted on wetter microsites.

This species should only be considered on fertile, sheltered and high rainfall sites, such as the northern foothills. It makes a good timber tree and is recommended by Poynton, (1979) for the mist-belt areas of the summer rainfall region of South Africa. It is also considered a suitable tree for shelterbelts and amenity purposes (Poynton, 1979). In Lesotho it could also be used as a low-grade pole, after treating with preservatives and for fuel.

P. pinaster

A tree of the Mediterranean region, generally being found on the coastal plains but extanding up to 2000m altitude in the Atlas mountains (Mirov, 1967 in Farjon, 1984). In Lesotho trials this species has only been represented by one seedlot from Portugal. Of six species in block plantings at Ha Foka, this species performed best. However, at a nearby pine species trial, the growth of *P. radiata* was very much better, giving a Yield Function eight times greater. At Pontseng this species showed poor survival, although those individuals that did survive grew reasonably quickly. At Paballong it had reasonable growth but very poor survival

However, in certain plantations, growth of *P. pinaster* has been satisfactory enough for it to be recommended, particularly in the foothills. Phillips, (1973) also recommends this species, particularly for higher rainfall localities in the foothills. Further testing of this species is required, with the Lesotho land race as a control.

P. pinea

This species has a wide distribution through southern Europe and Asia Minor. It is found from sea level to 1000m altitude (Poynton, 1979) In Lesotho, very poor growth but good survival seem to be characteristics of this species. In block plantings at Tsikoane and in trials at Phomolong and Ha Foka its survival was excellent. As a nut producing or ornamental species it may have some potential, where growth rate is not the major concern.

P. ponderosa

Widely distributed in western North America (Farjon, 1984). This species has shown promising results, compared with other conifers on the exposed mountain site at Semonkong. At the same site two seedlots of *P. radiata* failed completely. At the high altitude Pontseng site *P. ponderosa* var. *scopulorum* was the second best performing seedlot, but was much poorer in terms of growth and survival than *C. glabra*. The other seedlot (PP-78-COC) performed very badly. At the extreme altitude site at Letseng Mine, this species had failed after 12 years, but was probably killed by excessive livesock browsing. A seedlot of this species showed reasonable survival at the dry site of Paballong, but growth was poorer than the top performers, seedlots of *P. halepensis* and *P. brutia*.

At Ladybrand Plantation a *P. ponderosa* var. *arizonica* was recorded as being vigorous but short (Du Preez, 1942).

P. pseudostrobus

Naturally occurring in the highlands of southern Mexico and in the mountains of Guatemala and Honduras, at elevations of 1000m to 3000m. In Lesotho at a trial at Leshoboro Plateau three seedlots from OFI were tested against a South African seedlot of *P. radiata*. Growth of *P. pseudostrobus* was poor and survival pathetic compared with *P. radiata*. At Pontseng (Leribe) it failed completely and at Ha Mosuoe in the south survival was less than 10%.

This species has not performed well at any site and should not be considered for planting in Lesotho.

P. radiata

Naturally a rare pine of the central Californian coastline and the island of Guadelupe (Farjon, 1984). A very successful species in Lesotho, showing a great deal of adaptability, surviving and growing well on a wide variety of sites. It is not suitable however for very dry sites or waterlogged areas.

In most trials this species outperformed all other species, often by a large margin. However, it should not be planted on exposed, high mountain sites. At Pontseng at an altitude of 2270m the seedlot of *P. radiata* was one of three seedlots to have failed completely after 2 years. In the exposed mountain site of Khonyana Tsoana, at Semonkong all trees died. Also very dry sites, such as Paballong should be avoided, because of poor survival rather than disappointing growth.

Of the three older provenence and land race trials of South African or Lesotho seedlots (L/25/115 A to C) none showed statistical differences in height, dbh or survival, except at Tsereoane where differences in dbh were found to be statistically significant (Appendix 5). Using a multiple range test, the seedlots were divided into three groupings with considerable overlap (Appendix 5). When the performance was examined using the Yield Function or height x survival for Ha Ntsane large differences were observed between the seedlots. One seedlot of improved South African *P. radiata* was included, which showed good performance at Ha Ntsane and Leshoboro Plateau but not at Tsereoane. The most consistent performer was a Lesotho seedlot (PR83/1) from Bela-Bela.

Preliminary results at 28 months were analysed for provenance trials at Ha Khoarai and Molumong (L/25/126 A & B). Only one year results were available for Ha Mokhatla (L/25/126C)

At Ha Khoarai a provenance trial of *P. radiata* sited in the foothills on a gentle slope, with soil derived from basalt parent material, yielded interesting results. The huge block differences (Appendix 6) were explained by the design, as one of the three blocks was sited on ploughed ground, whereas the other blocks were established on pitted ground. Height growth in the ploughed area is about 3 to 4 times as great as in the pitted area. Survival was also found to be significantly lower in the pitted block. One seedlot, from Kiangoroa Forest (2/1/84/51/2) in New Zealand performed particularly well, giving the best performance in terms of height x survival. Analysing statistical differences in height, survival and height x survival, showed much overlap between seedlots. Performance of many did not show statistically significant differences. However two Lesotho seedlots were inferior to the best seedlots in terms of either survival (PR87/3) or in height growth (PR87/1). Again the results are too early for definite conclusions, but it is likely superior seedlots to those from Lesotho can be found for foothill sites.

At Molumong, a plateau site on sandstone derived soils, the fence around the trial had been cut and the area heavily grazed. The preliminary results were not statistically analysed but a Yield Function was calculated. Results indicate that there may be better seedlots than the Lesotho land races.

Ha Mokhatle, is situated in the drier south of the country, on a duplex soil. The P. radiata is in places looking yellowed and sickly and areas of the site are seasonally waterlogged. Only one year results were available, although it would appear that the Lesotho seedlot is not the best performer. The two best seedlots in terms of height x survival were Californian (12590) and from New Zealand (7/1/77/01/3).

P. rigida

A pine of the eastern USA, growing from sea level to about 900m (Farjon, 1984). In Lesotho this species was planted in 1979 at the Letseng Mine Site (3050m). Although identification was not certain, a few of these trees have survived till now, although they have been broken by cattle.

P. roxburghii

A tree native to the Himalayas, where it is found from at altitudes ranging from 400m to 2300m (Farjon, 1984). In its natural habitat rainfall varies from about 900m to about 3000mm, but in most of its range from 1000mm to 1800mm (Poynton, 1979). In Lesotho a provenance trial of this species at Tsereoane was closed early due to the poor growth of all provenances. A 1988 assessment shows many were defoliated by grasshoppers. At Phomolong height growth of the one seedlot tested was only slightly more than half that of P. radiata. Due to its high rainfall requirements it would be worth testing in the mist belt area, such as at Qacha's Nek. Its low frost tolerance makes it unsuitable for the mountains.

P. sabiniana

Found naturally in the dry foothills surrounding Central Valley in California. In Lesotho trials at Ha Foka and Pontseng (Leribe) this species showed unexceptional growth, but good survival. At the other Pontseng trial survival was bad and height growth half that of C. glabra. Early results were obtained from a trial at Paballong, where survival was reasonable, but growth was slow. This poor growth rate excludes this species from further work.

P. strobiformis

A tree of the Sierra Madre of Mexico and also in the southern USA (Farjon, 1984). In Lesotho this species did not survive at Pontseng (Leribe) and is not suitable for Lesotho conditions. At the high altitude Pontseng trial one seedlot failed completely, whilst the other's growth and survival was much poorer than C. glabra. At the Graziers Association site at Thaba Tseka two seelots showed reasonable to good survival, but very slow growth. This is not a suitable species for Lesotho.

P. taeda

The main commercial pine species of the south-eastern USA (Poynton, 1979). This species has performed inconsistently in Lesotho. It had excellent survival and growth at Hleoheng but had very poor survival at higher altitudes at Pontseng. At Hleoheng its growth rate was as good as the best species, P. radiata. Known to be tolerant to a range of soils it is however susceptible to drought (Poynton, 1979). This species may have potential on the better higher rainfall sites of the foothills, the north and in the Drakensberg mist belt. More testing is required before it can be recommended.

P. thunbergii

A native of Japan and south Korea (Farjon, 1984). Used extensively in Japan to stabilise soils and littoral dunes. Generally it is a tree of poor form and in South Africa, of slow growth. It is also noted as being very frost-hardy but unable to withstand drought (Poynton, 1979). As expected it showed unimpressive growth and survival in the dry south at Paballong and Ha Ramonate. Poor survival in the mountains at Pontseng and Libibing (Mokhotlong) and no survivors at Molumong (Mokhotlong). However, at Hleoheng a northern plateau site the growth was very good, although survival was only 50%. Worth testing in the mountains and in the mist belt as a species for soil conservation.

P. virginiana

A species that grows well in poor soils, but not those with calcareous substrate. Naturally distributed in the lowlands, below 300m, of the Atlantic Coastal Plain of the USA (Farjon, 1984). A possible species for soil conservation. In Lesotho trials there was complete failure of this species at Paballong, with no trees surviving. It showed better than average growth at Ramonate, but poor survival and was not an impressive performer at Pontseng (Leribe). Does not appear to be well suited to Lesotho conditions.

In addition to these species tested in trials, ten other pine species or subspecies have been planted, in Ladybrand Plantations, across the border in the Orange Free State. These pines comprised; P. coulteri, P. excelsa (now P. wallichiana), P. lindleyana (now P. montezumae var. lindleyana), P. longifolia, P. leiophylla, P. teocote, P. lawsoniana, P. nelsonii and P. laricio (now P. heldreichii) and P. signis (now P. radiata). A report by Du Preez, (1942) described the state of the compartments of these species: P. coulteri had only recently been planted, P. excelsa was considered hopelessly slowly. P. longifolia was described as being vigorous and healthy but P. leiophylla was very uneven and sparse and P teocte had considerable mortality following a drought period between 1928 and 1933. Good growth was achieved by P. lawsoniana, but the crop was sparse. The *P. nelsonii* was healthy but slow growing and had a tendency to fork. *P. laricio* was described as "very poor and branchy". When the report was written the *P. signis* had only recently been planted.

Cypresses

C. arizonica var. *glabra*

Recently five species have been relegated to variety status under the species *C. arizonica*. This species is found from Texas to central Arizona and southern California to northern Mexico (Krussmann, 1985).

In Lesotho this species is used extensively by the Forestry Division on harsh mountain sites. Although it can withstand severe cold and heavy browsing its growth rate is disappointing. At a trial at Thaba Tseka, at an altitude of 2 370m, it was only one of two species to have survival greater than 50% (Bazill, 1989). At another high altitude trial, Pontseng, 2 270m, after two years this species showed considerably better growth and survival than any other species tested.

Of the two provenance and land race trials that were planted, the Bushman's Pass experiment was closed early owing to excessive damage by rats, fires and browsing. However, five year results were available for Libibing, near Mokhotlong. Although differences in both height and survival were not statistically significant (Appendix 4), the Ladybrand land race showed the best height times survival. The Khanyane seedlot that performed best in the nursery, gave good growth but poor survival.

At the mountain site of Libibing the seedlot with the best height growth, from Syria only grew to a height of 1.34m in five years. A faster growing species must be found for the mountains.

Seedlots described as "*C. arizonica*" have also been planted by the Forestry Division, however the variety was not defined. Varieties other than *C. arizonica* var. *glabra* have not been tested in the trials.

C. sempervirens var. *horizontalis*

This species has proved to be tough, but like *C. arizonica* var. *glabra* its growth rate was disappointing. At Thaba Tseka (L/25/104) survival of a South african seedlot (26997) was better and growth as good as the best *C. glabra*. Large differences in both growth and survival were found at Pontseng (Leribe). The South African (26997) seedlot was better than the CSHC1 seedlot from Cyprus. Later investigations showed that the South african seedlot was *C. arizonica* var. *glabra*.

Six other cypresses have been grown 15km across the border at Ladybrand Plantation. These were *C. sempervirens* var. *sempervirens*, *C. benthamii*, *C. lusitanica*, *C. lindleyi* (now classified as *C. lusitanica*), *C. macrocarpa* and *C. funebris*. Of these *C. macrocarpa* was described as being "all dead". The *C. funebris* was in a mixture with *P. halepensis* and was being suppressed. The *C. lindleyi* crop was sparse, but producing good regeneration and the *C. benthamii* was sparse (Du Preez, 1942).

Other Conifers

Cedars

C. brevifolia

There were no individuals of this species surviving after 12 years at Letseng.

C. deodara

Although only in one trial at Letseng Mine, there is some experience of this species in Lesotho. In the lowlands, this species survives well but grows slowly. There is evidence from stumps at Ladybrand Plantations that this growth rate may increase later in the life of the tree (May, pers. comm). This species may be of use as an amenity tree or if sawlog plantations are adopted, as it produces a valuable timber. Heywood, (1908) was very enthusiastic about this species and its potential as a tree for prime sawn timber. Furthermore there are indications it is drought tolerant. In the 1935 Department of Agriculture Annual Report it was noted that *C. deodara* withstood the drought better than any other species (in May, 1990).

At Letseng Mine, at 3050m altitude this species survived the first year, but after twelve years there were no survivors.

Across the border at Ladybrand plantation, *C. libanii* was not vigorous.

Larix decidua

Three trees were found in the early trial at the Lesotho Youth Services camp at Thaba Tseka. They appeared healthy, but height growth was less than half that of *P. radiata*. It was noted that the larch's needles were already yellowing in March, indicating a period of effective photosynthesis of only 5 months (Experimental File Note).

Sequioadendron giganteum

After two years at Molumong (Mokhotlong) none of the trees had survived. However on less harsh sites they are known to grow in Lesotho. There are some fine old specimens of this tree at Qacha's Nek and one at the Sheep Stud at Quthing.

CONCLUSIONS

Many of the species tested in these trials have been represented by few seedlots and many of the trials are small and unreplicated. It is therefore difficult to completely dismiss many species. However there are certain species that have shown consistently good performance in trials and also in larger scale plantings. These can be recommended.

Pines

Although Phillips, (1973) considered it only for the lowlands, P. radiata has proved to be a plastic species and is the species most planted by the FD at present. It has been successful even in plantations on moderately exposed mountain sites. It will not however survive in exposed mountain conditions, such as at Semonkong. The suitability of this species to Lesotho conditions was realised as far back as 1908 (Heywood, 1908), when it was considered the most popular tree by the Protectorate Administration. Poynton, (1966) noted that this species was the most vigorous conifer in Lesotho. This species is suitable for soil conservation plantings, fuelwood and also for saw timber.

A trial of P. muricata, the close relative to P. radiata would be worthwhile. Seedlots should mainly be of the "blue form", which has performed well in New Zealand, (Wilcox, 1983). However the two seedlots tested in the Lesotho trials were not impressive in terms of growth or survival.

Despite the good results obtained with P. radiata, an effort should be made to diversify the FD pine planting and other species, especially P. greggii must be considered. Although not of the highest quality it does produce an acceptable timber and can continue to be grown for fuelwood. A provenance trial of P. greggii should be established, to test imported material against locally collected seed. To date there have been problems obtaining seedlots of this species.

The close relative of P. greggii, P. patula should only be planted on sites in the northern and central foothills and in the mist belt area of the south east as it is unable to withstand dry conditions. On these sites it can outperform P. radiata.

A further pine species for the foothills would be P. pinaster, which has shown good survival in plantations, although growth is slower than P. radiata.

A pine widely planted on the driest sites is P. halepensis which has proved to be a particularly hardy species, although its early growth rate is slow. Its main use may be rehabilitation of degraded sites, as it will survive and produce copious quantities of seed and natural regeneration. The same recommendations apply to its close relative P. brutia. In provenance trials in Australia the P. brutia complex was found to have faster growth and straighter stems than the P. halepensis group (Spencer, 1985). However P. brutia was found to be more sensitive to depth and type of soil, in particular in relation to drought and waterlogging. If these species are to be used extensively in the future, provenance trials in Lesotho would be advisable.

The poor results from P. eldarica are surprising as it is closely related to P. halepensis and P. brutia and is found on particularly dry, hot sites (Spencer, 1985). Trials in Italy have shown that P. eldarica was faster growing than its two close relatives and it may be worth testing again on dry sites.

Small blocks of P. densiflora and P. ponderosa should be considered in the mountains until faster growing alternatives are found. As P. ponderosa has the widest distribution of any pine in North America (Lowery, 1984), material from across its range should be tested. Results of conifers in the mountains have generally been disappointing and it is likely that other trees, such as willows and poplars will be better suited to the mountain conditions.

Heywood, (1908) suggested testing the following pines, which have not been represented in trials; P. coulteri, P. excelsa (now P. wallichiana), P. leptolepis and P. mitis. There are large, old specimens of P. coulteri in Lesotho and of P. excelsa across the border in Ladybrand. The P. excelsa at Ladybrand Plantation was noted as being healthy but slow (Du Preez, 1942). However on a recent visit May (pers. comm) found only one survivor, although the compartment is on a duplex soil. Also recommended, but noted as being even slower growing than P. halepensis is P. pinea. In lowland trials P. pinea has survived well but grown very slowly.

Poynton, (1986) proposes trying several more pine species; P. engelmannii, P. leiophylla, P. michoacana and P. teocote. The latter two particularly for the mountains. In Ladybrand Plantation, most trees of P. teocote died in droughts between 1928 and 1933.

Other pines worth trying include P. attenuata, P. aristata in the and P. peuce in the mountains. In the lowlands P. longifolia and P. lawsoniana would be worth investigating following favourable comments by Du Preez, (1942).

The hybrid between P. attenuata and P. radiata should be tested. This has been very successful in parts of the US and it appears that the hybrid exhibits much of the drought and frost hardiness of P. attenuata while retaining the fast juvenile growth of P. radiata (Oliver, 1979).

P. nelsonii a pine of the desert mountain ranges of Mexico would be worth testing, as a fuelwood and soil conservation tree.

Cypresses

The cypress, *C. arizonica* var. *glabra* has been shown to be a tough tree, withstanding severe climatic conditions and moderate browsing. Unfortunately it is very slow growing and the wood is not suitable for poles. At present it remains the tree most planted by the Forestry Division in the mountains. Seed from Ladybrand Plantation should continue to be used, as it showed best height x survival and is convenient to collect, being 15km from Maseru.

Poynton, (1986) recommends testing *C. lusitanica* and *C. torulosa*. There has been planting of *C. torulosa* in the past, but it is not represented in any of the trials. Heywood, (1908) suggests *C. macrocarpa* and *C. lusitanica* may be suitable for planting in Lesotho. Pryor, (1973) also notes *C. lusitanica* as being a possible species for Lesotho. This species should be tested, although Du Preez, (1943) described this species at Ladybrand Plantation, as being very slow.

Others

Lawson's Cypress, *Chamaecyparis lawsoniana* was noted growing in the mountains by Poynton, (1986) and would be worth investigating. May (pers. comm.) notes it has shown unimpressive growth in Mohale's Hoek.

Several conifer species were noted by Heywood (1908) as being worth considering planting in Lesotho; *Pseudotsuga menziesii*, *Juniperus bermudiana* and *J. virginiana*. Of these, *J. virginiana* is planted as an amenity tree in Maseru and so will survive in the lowlands. However, at Ladybrand Plantation it seems to have grown slowly and was generally supressed by other species (Du Preez, 1942). Other species suggested were *Callitris calcarata* (now *C. endlicheri*), *C. robusta* (now *C. preissii* ssp. *preissii*) and *Larix leptolepsis*. Both the *Callitris* species were grown in Ladybrand Plantation, and were described as being healthy but slow growing (Du Preez, 1943). At Quthing there are examples of *C. endlerichеri*. Both the *Callitris* species recommended can be found in the FD Arboretum. The few *Larix decidua* tested in Lesotho did not perform well. Poynton, (1986) suggested testing *Callitris glaucophylla* (now *C. columellaris*).

Seed of several North American conifers has been sown at the Research Nursery, unfortunately almost all seedlings died, when small. After advice from the pathologist at the University of the Orange Free Statae, soil from under pine plantations was mixed in to try to ensure that general conifer mycorrhizae were present in the potting mixture. They have been sown again this year and some, particularly *P. menziezii* does not appear to be healthy. Records show that this species has failed in the nursery in the past. Research in the USA has shown that survival of this species is greatly improved when shading and protection from wind is provided (Read and Sprakling in Van Haverbeke, 1987).

There are considered to be two varieties of P. mensiezii, coastal and Rocky Mountain. Both cover a wide variety of soil types and climates (Borman, 1984).

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Appendix 1
Lowland Trials (<1800m)

Results,
Analysis
&
Summary

Introduction

Most of the conifer trials established in Lesotho were in the lowlands. This appendix reviews the results of 11 trials:

Ha Foka L/25/77 and L/25/77a
Hleoheng L/25/91
Leshoboro L/25/96
Ha Mosuoe L/25/87 and L/25/87a
Pabalong L/25/88
Ha Ramonate L/25/78 and L/25/78b
Tsikoane L/25/98 and L/25/98a

These trials vary in altitude, from 1500m to 1800m.

Results

Results are displayed in Tables A1.1 to A1.11 and Yield Function or Height x Survival in Figures A1.1 to A1.7. ANOVAR was applied to the data for Hleoheng (L/25/91), Ha Foka Pines (L/25/77) and Ha Ramonate pines (L/25/78b).

Discussion

The lowest altitude trials, at 1500m were at Ha Mosuoe, near the Senqu River in the south of Lesotho. The results from the conifer trial were surprising, because it is a low rainfall area, (c 650mm) with best growth and Yield Function from P. radiata and P. greggii. Best survivors were C. glabra, P. halepensis and P. brutia.

Two trials were established at Ha Ramonate, also in the south, at an altitude of 1570m and are also on a dry site. At the Conifer Trial (L/25/78b) site the only species with reasonable growth was P. radiata. Survival generally was very poor, the best surviving species being P. brutia. However, this species had grown less than 3m in 8.5 years. Despite the poor survival, P. radiata has the greatest Yield Function. (L/25/78), a replicated trial gave statistically different results for height, dbh and survival between species. Only one species, P. patula was found to have significantly poorer survival than the others. The survival of P. patula was particularly poor, although growth of the few survivors was the best in terms of dbh and best, with a South African seedlot of P. roxburghii in terms of height. The survival of P. roxburghii was excellent also and this species was certainly the best adapted to this site, of the species tested. As expected, P. halepensis was a good survivor, but growth was not impressive. Other species tested, P. eldarica, P. pinea and in a side planting, P. canariensis also showed poor growth but good survival. It is a pity that P. radiata was not included as a control, as it is unlikely that any of these other species would perform as well.

Paballong, at 1600m is situated in the dry south. Preliminary results show the superior survival of the very drought hardy P. halepensis and P. brutia. Other pine species were not able to tolerate the dry conditions, and survival has generally been poor. Seven of the thirty seedlots have failed completely. None of the cypresses showed good survival, in contrast to Ha Mosuoe.

Hleoheng is a plateau site, in the north, at an altitude of 1740m. An ANOVAR showed statistical differences in height, dbh and survival between seedlots. Species in the best performing groups for height and dbh and survival were P. radiata, P. taeda, P. patula and P. greggii (Fig A1.3 and Tables A1.15 and A1.16).

Ha Foka, is situated at an altitude of 1780m in the northern lowlands. In the pine trial growth of P. radiata was vastly superior to the other species, except P. patula. The survival of P. patula was however pathetic. All other species showed poor growth, with P. roxburghii being the best. Surprisingly survival of P. halepensis was very poor.

Unfortunately in the block plantings at Ha Foka, P. radiata was not planted as a control and from experience from other trials none of the species in these pine block plantings were likely to grow as quickly as P. radiata. Two species failed completely, P. muricata and P. monticola. The species with best growth was P. pinaster, while P. ponderosa gave best survival.

Tsikoane is another northern plateau site, at an altitude of 1800m. Three year results of bulk plots of 12 pine seedlots, showed that P. greggii was well suited to the site. Unfortunately, P. radiata was not represented in these plantings. The generally high survivals indicate that a wide range of species can be planted on this site, but the data for heights show the superiority of P. greggii over the other pines tested. A Jordanian seedlot of P. halepensis, PHJ1 grew and survived particularly poorly and should be avoided.

Leshoboro is a plateau site close to Maseru at an altitude of 1800m. Bulk plots were established of P. greggii and P. montezumae. At age 5.5 years the survival of P. montezumae was better, but the faster growth of P. greggii more than compensated for this. Furthermore, for sawn timber the survival of P. greggii may be adequate.

FIGURE A1.1

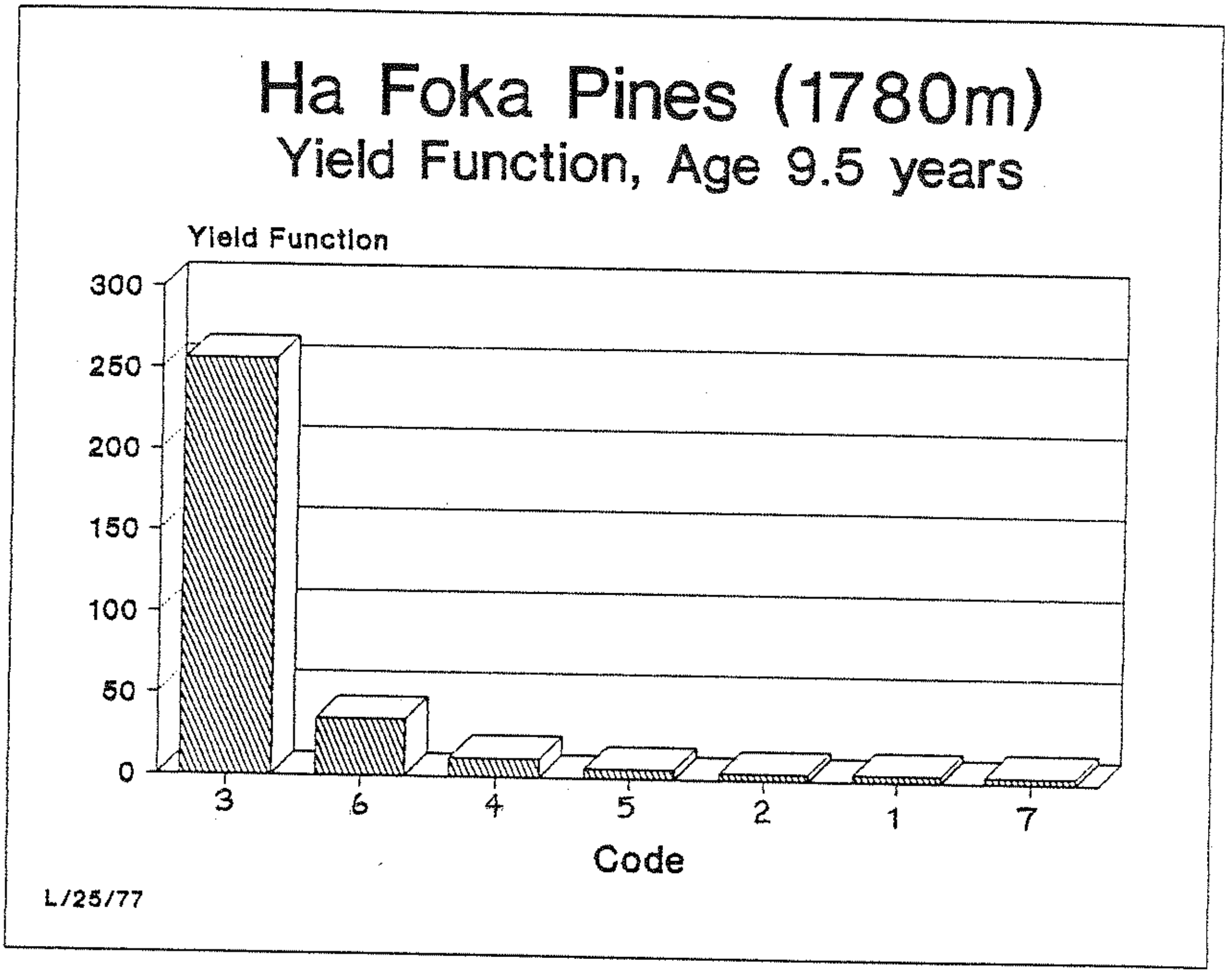

Table A1.1 Ha Foka Pine Trial L/25/77 Age 9.5 years

Code	Species	Seedlot	Dhh	Height	Survival	Yield F.
1	P. halepensis	29278	6	4	27	3.89
2	P. eldarica	PE-77-PK	5.2	3.3	45	4.02
3	P. radiata	RSA	17.9	9.4	85	256.01
4	P. pinea	26479	6.4	3.3	85	11.49
5	P. brutia	Cyprus	5.4	3.1	63	5.69
6	P. roxburghii	123	9.4	4.5	87	34.59
7	P. patula	RSA	13.1	7.2	3	3.71

TABLE A1.4 Analysis of Variance for HAFOKAPI.HEIGHT

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	182.03495	10	18.203495	14.553	.0000
HAFOKAPI.CODE	172.91729	6	28.819548	23.041	.0000
HAFOKAPI.BLOCK	13.91676	4	3.479190	2.782	.0534
RESIDUAL	26.267238	21	1.2508209		
TOTAL (CORR.)	208.30219	31			

3 missing values have been excluded.

TABLE A1.5 Multiple range analysis for HAFOKAPI.HEIGHT by HAFOKAPI.C

Method: 95 Percent Confidence Intervals

Level	Count	Average	Homogeneous Groups
4	5	2.9800000	*
0	5	3.2000000	*
1	5	3.2800000	*
3	5	3.2800000	*
5	5	4.5400000	**
6	2	7.2000000	**
2	5	9.3800000	*

TABLE A1.2 Analysis of Variance for HAFOKAPI.DBH

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	739.41285	10	73.94128	12.626	.0000
HAFOKAPI.CODE	721.87314	6	120.31219	20.543	.0000
HAFOKAPI.BLOCK	20.51010	4	5.12752	.876	.4952
RESIDUAL	122.98590	21	5.8564717		
TOTAL (CORR.)	862.39875	31			

3 missing values have been excluded.

TABLE A1.3 Multiple range analysis for HAFOKAPI.DBH by HAFOKAPI.C

Method: 95 Percent Confidence Intervals

Level	Count	Average	Homogeneous Groups
4	5	4.400000	*
0	5	4.800000	*
1	5	5.220000	**
3	5	6.420000	**
5	5	9.380000	**
6	2	13.100000	**
2	5	17.940000	*

TABLE A1.6 Analysis of Variance for HAFOKAPI.SURVIVAL

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	33509.029	10	3350.9029	11.411	.0000
HAFOKAPI.CODE	31123.486	6	5187.2476	17.665	.0000
HAFOKAPI.BLOCK	2385.543	4	596.3857	2.031	.1220
RESIDUAL	7047.6571	24	293.65238		
TOTAL (CORR.)	40556.686	34			

0 missing values have been excluded.

TABLE A1.7 Multiple range analysis for HAFOKAPI.SURVIVAL by HAFOKAPI.C

Method: 95 Percent Confidence Intervals

Level	Count	Average	Homogeneous Groups
6	5	3.200000	*
0	5	21.400000	**
1	5	45.000000	**
4	5	60.000000	**
2	5	75.000000	**
3	5	85.000000	*
5	5	86.600000	*

TABLE A1.8 Analysis of Variance for HAFOKPIN.TRANSURV

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	5.4201165	10	.5420116	9.469	.0000
HAFOKPIN.CODE	4.9969708	6	.8328285	14.549	.0000
HAFOKPIN.BLOCK	.4231456	4	.1057864	1.848	.1525
RESIDUAL	1.3738268	24	.0572428		
TOTAL (CORR.)	6.7939433	34			

0 missing values have been excluded.

TABLE A1.9 Multiple range analysis for HAFOKPIN.TRANSURV by HAFOKPIN.C

Method: 95 Percent Confidence Intervals

Level	Count	Average	Homogeneous Groups
6	5	.0320342	*
0	5	.2171956	**
1	5	.5006720	**
4	5	.6739321	**
2	5	.8843361	**
3	5	1.0284677	*
5	5	1.1090309	*

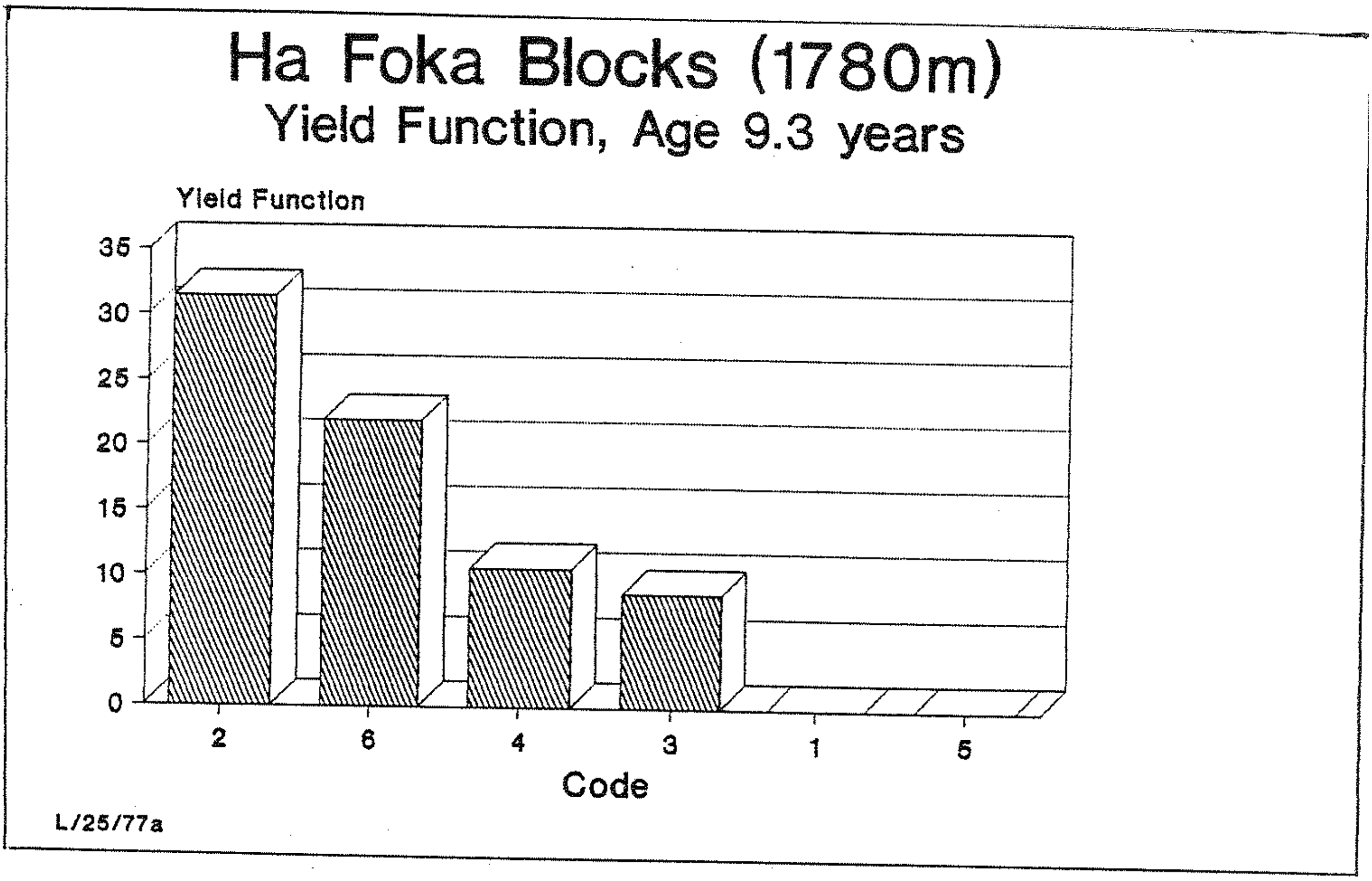

Table 1.10 Ha Foka Block Plantings L/25/77a, Age 9.3 years

Code	Species	Seedlot	Dbh	Height	Survival	Yield F.
1	P. muricata	R1004	0	0	0	0.00
2	P. pinaster	28558	11	5.2	50	31.46
3	P. sabiniana	26484	5.2	3.9	83	8.75
4	P. pseudostrobus	R1003	7.5	4.4	43	10.64
5	P. monticola	USA	0	0	0	0.00
6	P. ponderosa	USA	7.6	3.8	100	21.95

FIGURE A1.3

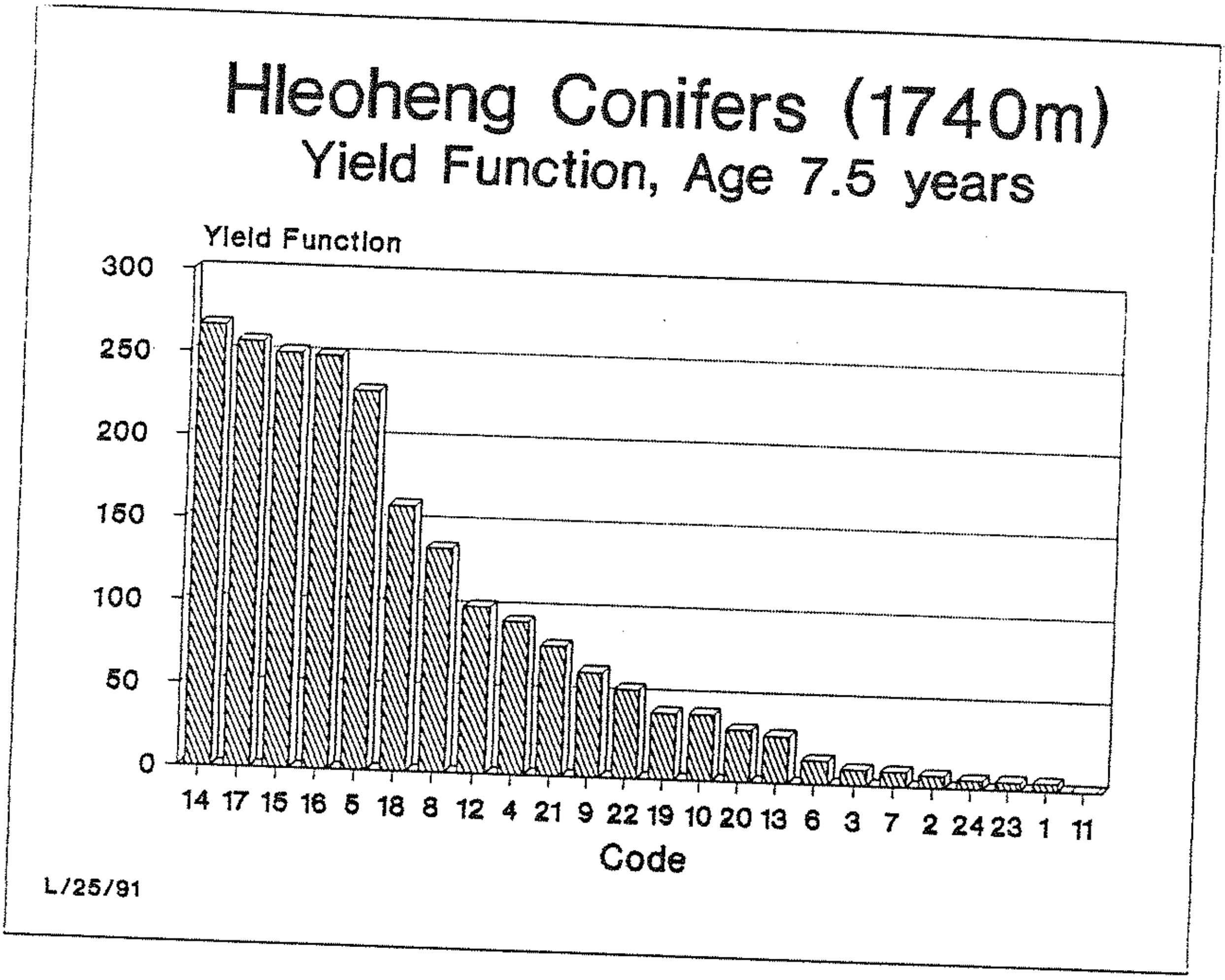

Table A1.11 Hleoheng Conifer Trial L/26/91 Age 7.5 years

Code	Species	Seedlot	Dbh	Height	Survival	Yield F.
1	P. brutia	594	4.1	3.2	85	4.57
2	P. brutia	PBC1	4.8	3.6	85	7.05
3	P. eldarica	PE77PIC	6.3	3.8	60	9.05
4	P. elliottii	28698	14.9	6.9	60	91.91
5	P. greggii	P991	18.9	8.9	72	228.90
6	P. halepensis	29278	6.1	3.8	98	13.86
7	P. halepensis	PH81	5	3.5	98	8.57
8	P. montezumae	30598	16.2	6.2	83	135.05
9	P. muricata	R1004	12.4	15.6	72	172.70
10	P. muricata	PMC1	10.8	5	68	39.66
11	P. nigra	404	1.1	0.9	12	0.01
12	P. patula	29810	17.3	8.4	40	100.56
13	P. patula	R1008	12.6	6.3	28	28.01
14	P. radiata	26209	19	8.9	83	266.67
15	P. radiata	30647	17.6	9	90	250.91
16	P. radiata	Lesotho	19.2	9.4	72	249.50
17	P. taeda	28442	17.7	8.2	100	256.90
18	P. thunbergii	PTK1	17.9	10	50	160.20
19	P. virginiana	13207	9.8	4.6	90	39.76
20	P. densiflora	PDK1	12.4	3.2	63	31.00
21	P. maximinoi	3077	13.6	7.7	55	78.33
22	C. glabra	30524	10.7	5.8	8	5.31
23	C. horizontalis	CSHC1	7.5	4.8	68	18.36
24	C. horizontalis	26997	4.4	3.3	80	5.11

TABLE A1.12 Analysis of Variance for HLEOCON.HEIGHT

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	534.50437	26	20.557860	39.563	.0000
HLEOCON.BLOCK	.83272	3	.277572	.534	.6604
HLEOCON.CODE	533.41614	23	23.192006	44.633	.0000
RESIDUAL	35.333949	68	.5196169		
TOTAL (CORR.)	569.83832	94			

1 missing values have been excluded.

TABLE A1.13 Analysis of Variance for HLEOCON.SURVIVAL

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	49927.744	26	1920.2978	4.553	.0000
HLEOCON.BLOCK	5153.821	3	1717.9404	4.073	.0101
HLEOCON.CODE	44488.640	23	1934.2887	4.586	.0000
RESIDUAL	28680.845	68	421.77714		
TOTAL (CORR.)	78608.589	94			

1 missing values have been excluded.

TABLE A1.14 Analysis of Variance for HLEOCON.DBH

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	3173.7166	26	122.06602	29.318	.0000
HLEOCON.BLOCK	13.0200	3	4.34001	1.042	.3795
HLEOCON.CODE	3157.2757	23	137.27286	32.971	.0000
RESIDUAL	283.11663	68	4.1634799		
TOTAL (CORR.)	3456.8333	94			

1 missing values have been excluded.

TABLE A.15 Multiple range analysis for HLEOCON.HEIGHT by HLEOCON.CO

Method: 95 Percent Confidence Intervals

Level	Count	Average	Homogeneous Groups
11	4	.9250000	*
18	4	3.0500000	*
20	4	3.2000000	**
1	4	3.2500000	**
24	4	3.3250000	**
7	4	3.4750000	**
2	4	3.6000000	***
23	3	3.6333333	****
3	4	3.8250000	****
6	4	3.8500000	****
19	4	4.6250000	****
10	4	4.9750000	****
22	4	5.0750000	***
9	4	5.6750000	***
8	4	6.1750000	**
13	4	6.3250000	***
4	4	6.8750000	***
21	4	7.7000000	***
17	4	8.1750000	***
12	4	8.4500000	**
5	4	8.8750000	**
14	4	8.9250000	**
15	4	8.9750000	**
16	4	9.4250000	*

TABLE A.16 Multiple range analysis for HLEOCON.SURVIVAL by HLEOCON.CO

Method: 95 Percent Confidence Intervals

Level	Count	Average	Homogeneous Groups
11	4	12.500000	*
13	4	27.500000	**
12	4	40.000000	***
18	4	50.000000	****
21	4	55.000000	***
3	4	60.000000	****
4	4	60.000000	****
20	4	62.500000	****
10	4	67.500000	****
19	4	69.500000	***
5	4	72.500000	***
9	4	72.500000	***
16	4	72.500000	***
24	4	80.000000	***
8	4	82.500000	**
14	4	82.500000	**
1	4	85.000000	**
2	4	85.000000	**
23	3	86.666667	**
15	4	90.000000	**
22	4	90.000000	**
6	4	97.500000	*
7	4	97.500000	*
17	4	100.000000	*

FIGURE A1.4

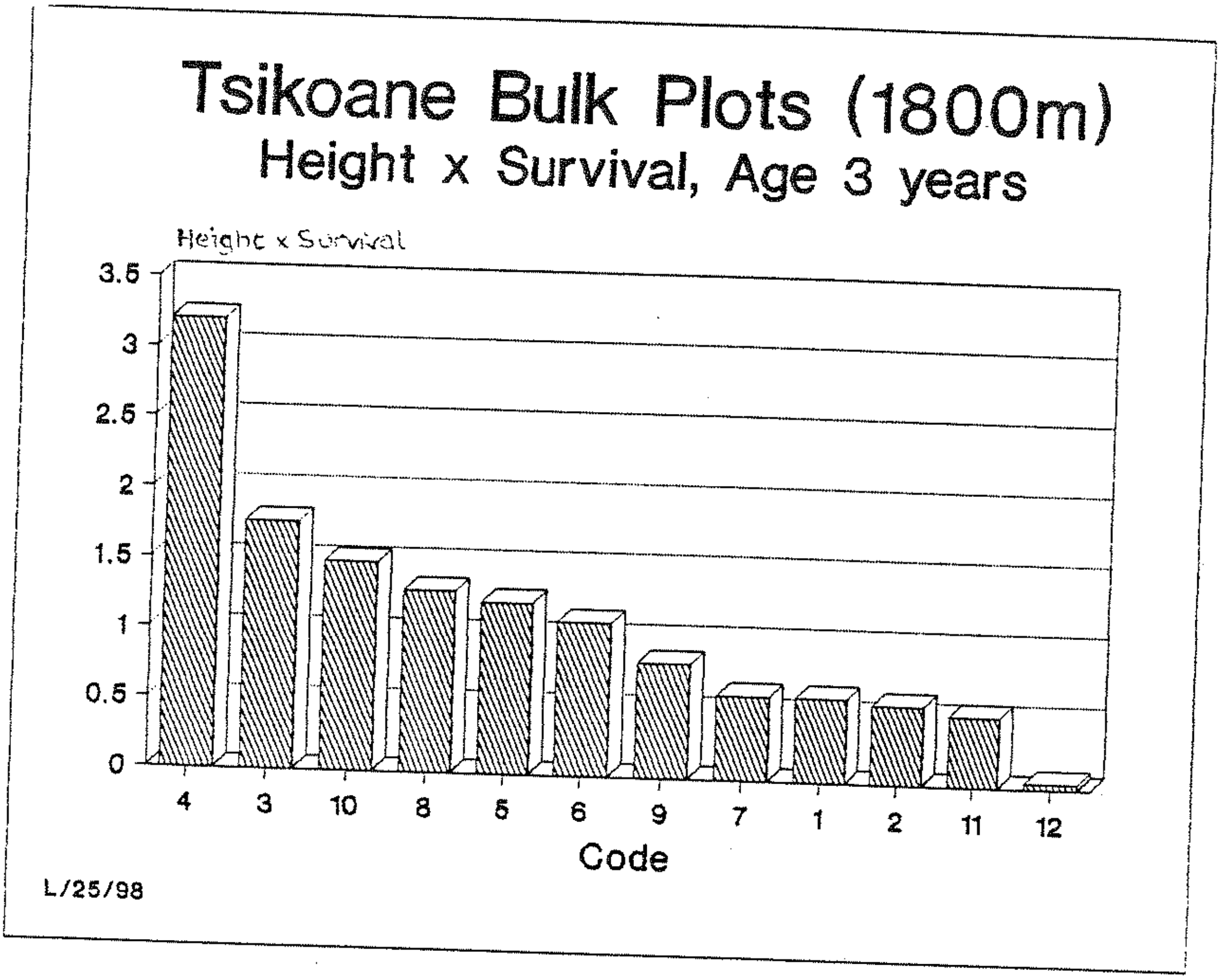

Table A1.18 L/25/98 Tsikoane Bulk Plots Age 3 years

Code	Species	Seedlot No.	Height	Survival	Ht X Surv
1	P. brutia	PBC1	0.83	72.5	0.60
2	P. brutia	594	0.71	79	0.56
3	P. eldarica	PE-77-PK	2.01	88	1.77
4	P. greggii	PGG1	3.56	89.5	3.19
5	P. halepensis	PHG1	1.33	92.4	1.23
6	P. halepensis	29278	1.26	86.9	1.09
7	P. montezumae	30598	1.34	45	0.60
8	P. muricata	PMC1	1.66	78	1.29
9	P. muricata	R1004	1.22	66.5	0.81
10	P. patula	29810	2.13	70	1.49
11	P. pinea	30634	0.69	72	0.50
12	P. halepensis	PHJ1	0.49	8	0.04

Table A1.19 Leshoboro Bulk Plots Age 5.5 years

Code	Species	Seedlot	Dbh	Height	Survival	Yield F.
1	P. greggii	PGG1	9.8	5.9	44	24.93198
2	P. montezumae	30595	6	2.8	63	6.3504

FIGURE A1.5

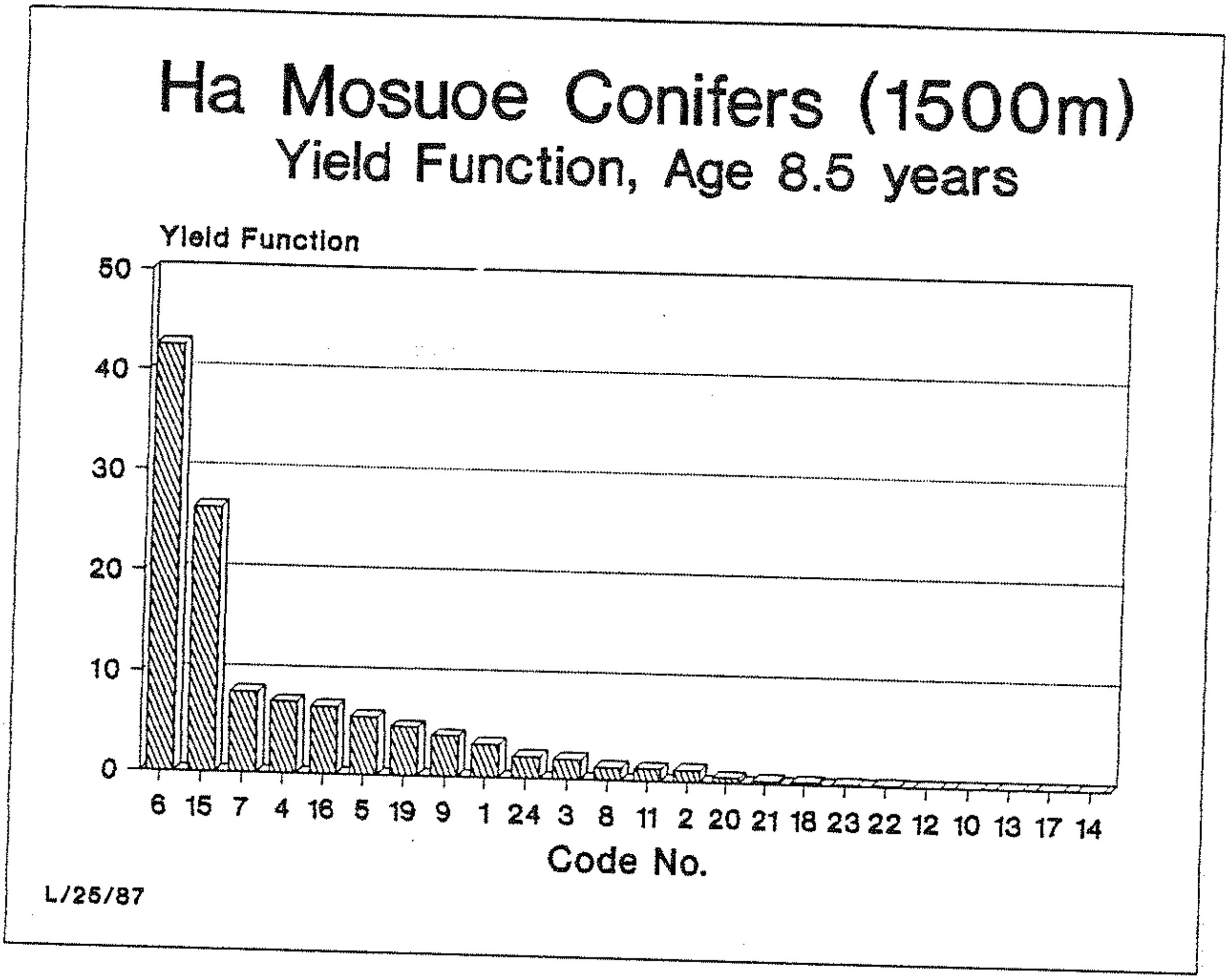

Table A1.20 Conifer Trial at Ha Musuoe L/25/87 Age 8.5 years

Code	Species	Seedlot	Dbh	Height	Survival	Yield F.
1	P. brutia	594	4.3	2.9	61	3.27
2	P. brutia	PBC1	4.2	2.6	25	1.15
3	P. echinata	110-33	7.9	3.9	8	1.95
4	P. eldarica	P-77-PK	7.3	3.7	36	7.10
5	P. elliottii	28693	10.2	5	11	5.72
6	P. greggii	PGG1	14.1	6.9	31	42.53
7	P. halepensis	29278	5.8	4.1	58	8.00
8	P. halepensis	PHG1	3	2.1	64	1.21
9	P. montezume	30598	9.3	4.2	11	4.00
10	P. muricata	R1004	0	0	0	0.00
11	P. muricata	PMC1	4.6	2.9	19	1.17
12	P. nigra	404	0	0	0	0.00
13	P. patula	29810	0	0	0	0.00
14	P. patula	R1008	0	0	0	0.00
15	P. radiata	26209	11.8	6.1	31	26.33
16	P. radiata	30647	7.9	4.9	22	6.73
17	P. taeda	28442	0	0	0	0.00
18	P. thunbergii	PTK1	5	3	2.8	0.21
19	P. virginiana	132-07	7.2	3.7	25	4.80
20	C. glabra	CGC1	1.6	2.5	70	0.45
21	C. glabra	30524	1.1	2.7	69	0.23
22	C. horiz	CSHC1	0.9	1.1	44	0.04
23	C. horiz	36977	1.1	1.5	46	0.08
24	P. pseudostrobus	3077	7.4	4.6	8.3	2.09

FIGURE A.1.6

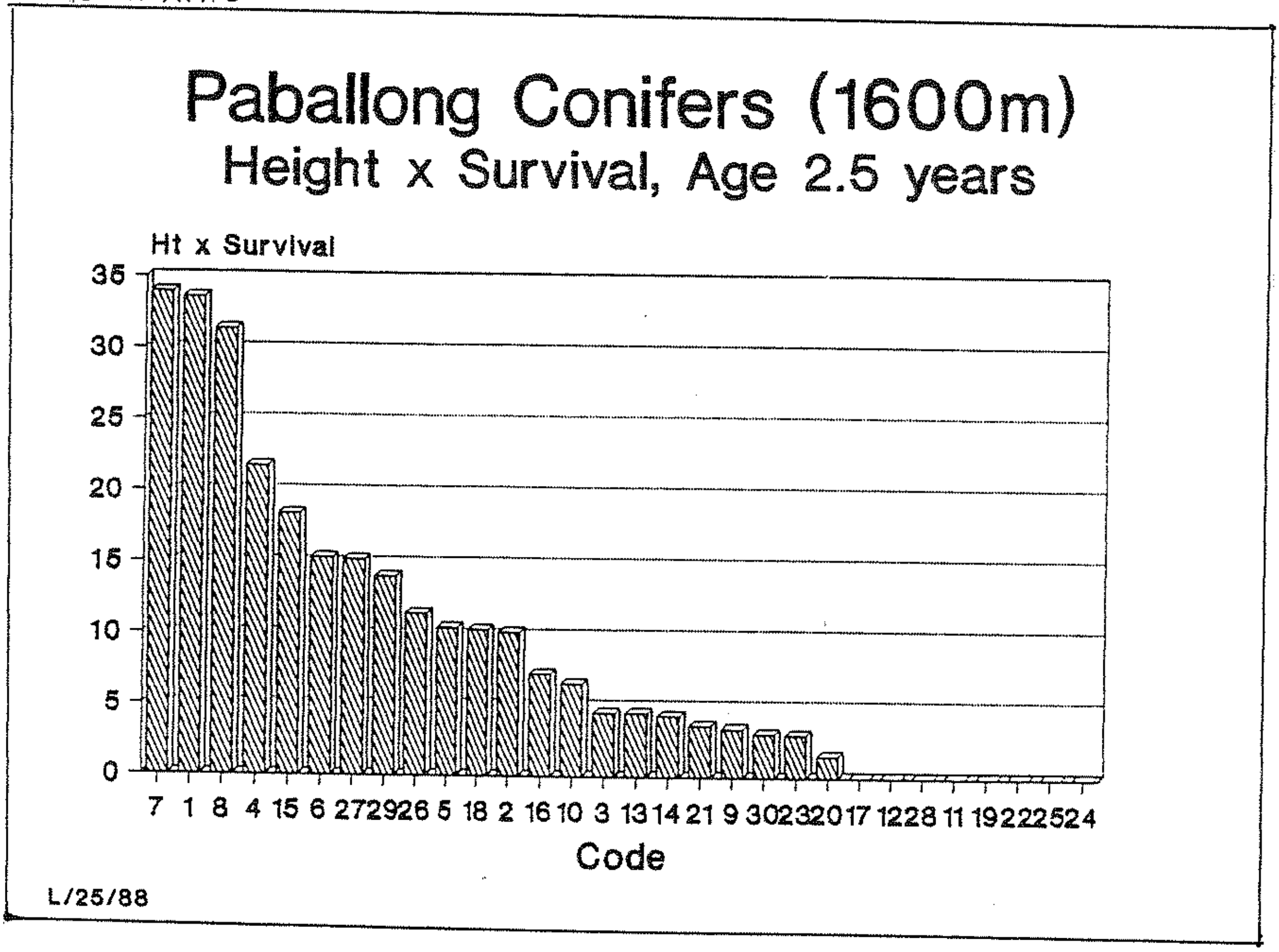

Table A1.21 Paballong Conifer Trial L/25/88 Age 2.5 years

Code	Species	Seedlot	Height	Survival	Ht X Surv
1	P. brutia	594	0.37	90	0.33
2	P. brutia	PBC1	0.50	20	0.10
3	P. echinata	110-33	0.45	10	0.04
4	P. eldarica	PE-77-PK	0.48	45	0.22
5	P. elliottii	28693	0.52	20	0.10
6	P. greggii	PGG1	0.76	20	0.15
7	P. halepensis	29278	0.38	90	0.34
8	P. halepensis	PHG1	0.35	90	0.31
9	P. montezumae	30598	0.68	5	0.03
10	P. muricata	R1004	0.65	10	0.07
11	P. muricata PMC1	PMC1	0.00	0	0.00
12	P. nigra	404	0.00	0	0.00
13	P. patula	29810	0.45	10	0.04
14	P. patula	R1008	0.43	10	0.04
15	P. radiata	26209	0.61	30	0.18
16	P. radiata	30647	0.72	10	0.07
17	P. taeda	28442	0.00	0	0.00
18	P. thunbergii	PTK1	0.34	30	0.10
19	P. virginiana	132-07	0.00	0	0.00
20	C. glabra	CGE1	0.15	10	0.01
21	C. glabra	30524	0.36	10	0.04
22	C. horizontalis	CSHC1	0.00	0	0.00
23	C. horiz	26997	0.30	10	0.03
24	P. maximinoi	30/77	0.00	0	0.00
25	P. jeffreyi	No 1	0.00	0	0.00
26	P. pinaster	28558	0.57	20	0.11
27	P. ponderosa	PP-78-COC	0.25	60	0.15
28	P. strobiformis	PS-78-COC	0.00	0	0.00
29	P. sabiniana	Italy	0.21	66.7	0.14
30	P. halepensis	PHJ1	0.40	7.8	0.03

FIGURE A1.7

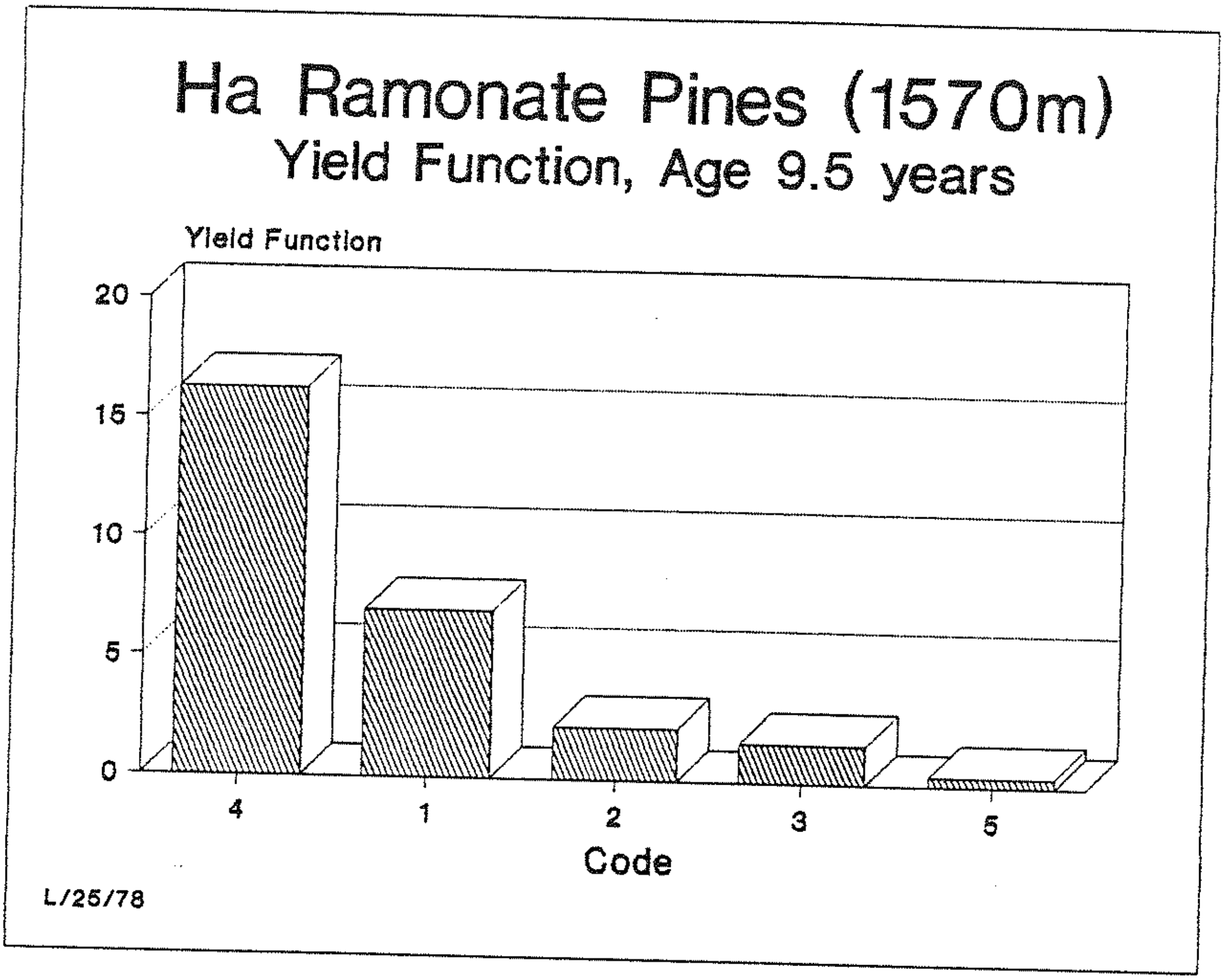

Table A1.12 Ha Ramonate Pines Age 9.5 years

Code	Species	Seedlot	Dbh	Height	Survival	Yield F.
1	P. halepensis	29278	4.8	3.1	98	7.00
2	P. eldarica	PE-77-PK	3.4	2.1	90	2.18
3	P. pinea	26497	3	2	90	1.62
4	P. roxburghii	123	7.2	3.2	98	16.26
5	P. patula	29810	6.7	4.4	2	0.40
6	P. canariensis	R1003	3.9	2.4	100	3.65

P. canariensis is in a side planting

TABLE A1.23 Analysis of Variance for RAMPINE.HEIGHT

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	9.3893810	8	1.1736726	11.331	.0002
RAMPINE.BLOCK	.5170000	4	.1292500	1.248	.3428
RAMPINE.CODE	8.1500000	4	2.0375000	19.670	.0000
RESIDUAL	1.2430000	12	.1035833		
TOTAL (CORR.)	10.632381	20			

4 missing values have been excluded.

TABLE A1.24 Multiple range analysis for RAMPINE.HEIGHT by RAMPINE.CO

Method: 95 Percent Confidence Intervals

Level	Count	Average	Homogeneous Groups
3	5	2.0000000	*
2	5	2.1200000	*
1	5	3.1000000	*
4	5	3.1600000	*
5	1	4.4000000	*

TABLE A1.25 Analysis of Variance for RAMPINE.DBH

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	61.311381	8	7.663923	14.278	.0000
RAMPINE.BLOCK	3.967000	4	.991750	1.848	.1846
RAMPINE.CODE	58.164500	4	14.541125	27.091	.0000
RESIDUAL	6.4410000	12	.5367500		
TOTAL (CORR.)	67.752381	20			

4 missing values have been excluded.

TABLE A1.26 Multiple range analysis for RAMPINE.DBH by RAMPINE.CO

Method: 95 Percent Confidence Intervals

Level	Count	Average	Homogeneous Groups
3	5	2.9600000	*
2	5	3.4400000	**
1	5	4.7600000	**
5	1	6.7000000	**
4	5	7.1600000	*

TABLE A1.27 Analysis of Variance for RAMPINE.TRANSURV

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	7.7324890	8	.9665611	15.783	.0000
RAMPINE.BLOCK	.1745673	4	.0436418	.713	.5953
RAMPINE.CODE	7.5579218	4	1.8894804	30.853	.0000
RESIDUAL	.9798662	16	.0612416		
TOTAL (CORR.)	8.7123552	24			

0 missing values have been excluded.

TABLE A1.28 Multiple range analysis for RAMPINE.TRANSURV by RAMPINE.CO

Method: 95 Percent Confidence Intervals

Level	Count	Average	Homogeneous Groups
5	5	.0160171	*
2	5	1.2273686	*
3	5	1.2273686	*
1	5	1.4902532	*
4	5	1.4902532	*

Appendix 2
Foothill Trials (1800m - 2000m)

Results,
Analysis
&
Summary

Introduction

The foothills are poorly represented in the trials, however there is considerable experience of planting a wide range of species in Forest Reserves. The results of only one trial at Phomolong are discussed in this appendix.

Results

The results of the trial are shown in Table A2.1 and the Yield Function graphically in Figure A2.1.

Discussion

Survival in this trial was generally poor. This was surprising as in neighbouring management plantings of P. pinaster and P. radiata have good stocking. The best growth, by far, was achieved by P. radiata. The best surviving species was P. pinea, however growth was slow, an average height of 2.6m being attained after 8.5 years. The poor growth and survival of P. patula was unexpected, especially as there are other areas at Phomolong with healthy, vigorous P. patula. Survival of less than 20% for P. halepensis was also surprising as this is one of the most robust conifers in Lesotho. Notes made after the first assessment indicate that the fence had been cut and many of the trees had been damaged through browsing, which would explain the very poor survival.

FIGURE A2.1

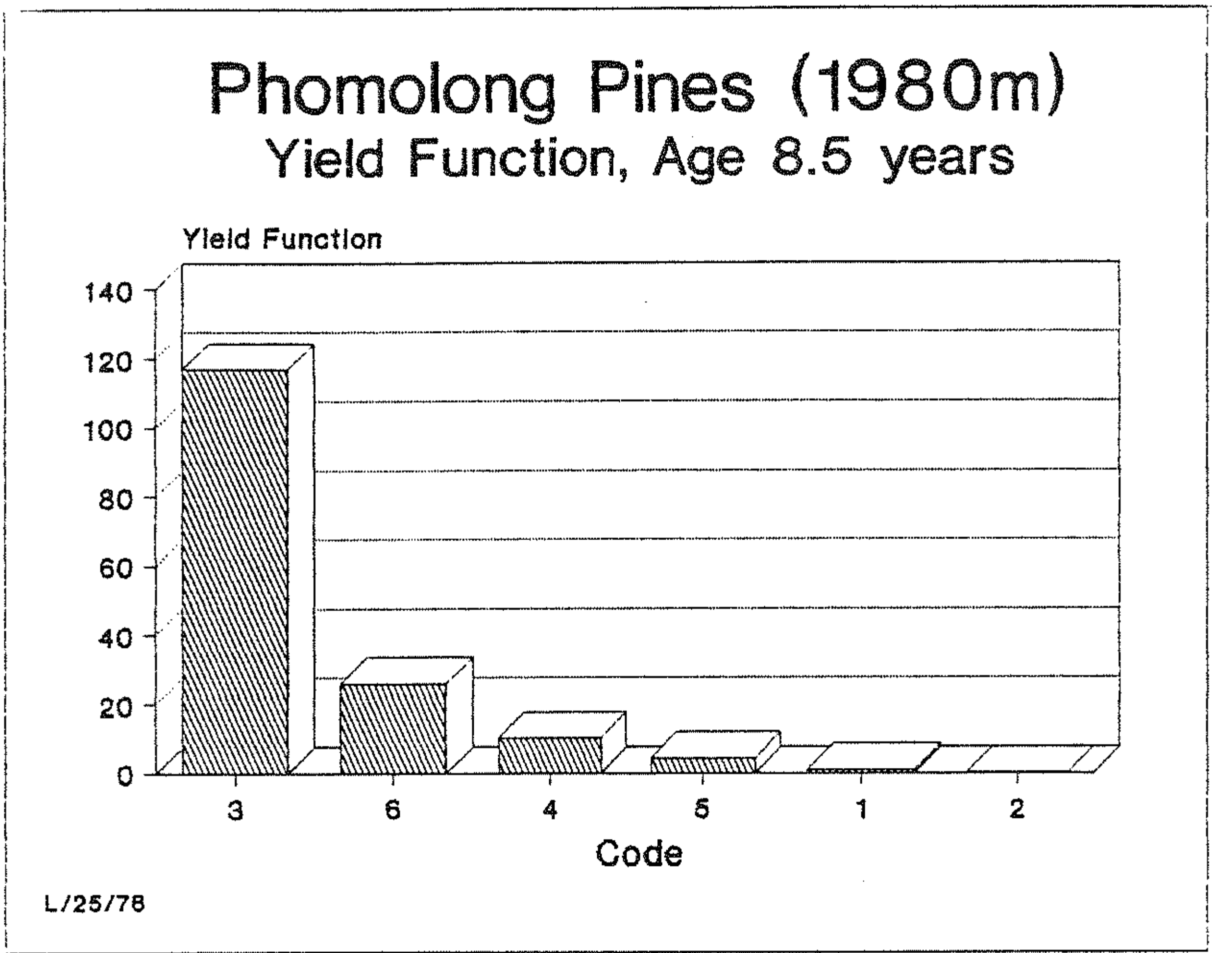

TABLE A2.1
Phomolong pines L/25/76 Age 8.5 years

Code	Species	Seedlot	Dbh	Height	Survival	Yield F
1	P. eldarica	PE-77-PK	7.2	2.93	6.7	1.02
2	P. halepensis	29278	1	0.81	18.3	0.01
3	P.radiata(30647)	30647	23.3	7.6	28.3	116.76
4	P. roxburghii	123	10.7	4.4	20	10.08
5	P. pinea	26479	5.6	2.6	53.3	4.35
6	P. patula	ex-RSA	15	6.9	16.7	25.93

6

Appendix 3
Mountain Trials (> 2000m)

Results,
Analysis
&
Summary

Introduction

The results of six trials are described in this appendix:

Konyana Tsoana L/25/131
Letseng Mine L/25/31
Pontseng Pines L/25/80
Pontseng Conifers L/25/80a
Pontseng (Mokhotlong) Conifers L/25/102
Thaba Tseka conifers L/25/104

They cover an altitude range of 1900m at Pontseng to 3050m at Letseng. Pontseng because of its exposure has been included as a mountain trial rather than a foothill trial.

Results

Results are presented in Tables A3.1 to A3.5 and height x survival or Yield Function are graphically displayed in Figures A3.1 to A3.5. Results for Letseng Mine are described in the discussion.

Discussion

In the low mountains there are several species which show reasonable growth and survival. At Pontseng four pines were found to be particularly well adapted to the low mountain conditions; P. radiata, P. greggii, P. montezumae and P. patula.

As altitude increases the survival of these species is reduced to unacceptable levels. At Thaba Tseka (2270m) survival of these four pines was zero. However, survival of the slow-growing cypresses, C. glabra and C. sempervirens var. horizontalis varied from very poor to good. South African seedlots proved to be best. The trial at Konyana Tsoana the C. glabra showed poor survival and had not increased in height after a year, whilst several pine species exhibited modest height growth. Best performance was from P. ponderosa. The reason for the poor results of C. glabra at Pontseng is not known. Certainly at Pontseng (Mokhotlong) the growth and survival of C. glabra bettered all other species by a large margin. Over 2200m, C. glabra is the recommended conifer for fuelwood, except on unusually sheltered sites.

At the ultra high altitude site at Letseng Mine (3050m) three pine species, P. mugo, P. contorta and P. rigida had survived the severe conditions for over 11 years, although height growth was less than 1.5m. Recently many were killed by cattle. In June 1990 further species were planted, including two conifers, Widdringtonia noidiflora and P. ponderosa. The P. ponderosa was very poor stock, being overgrown and lacking mycorrhizae in the nursery. However it had survived the first year. The widdrintonia had died. Other non-conifer species, such as Salix sp. and Leucosidea sericea were planted. The only L. sericea plant and most of the willows had survived the second year, although the L. sericea was frosted back each winter.

FIGURE A3 1.

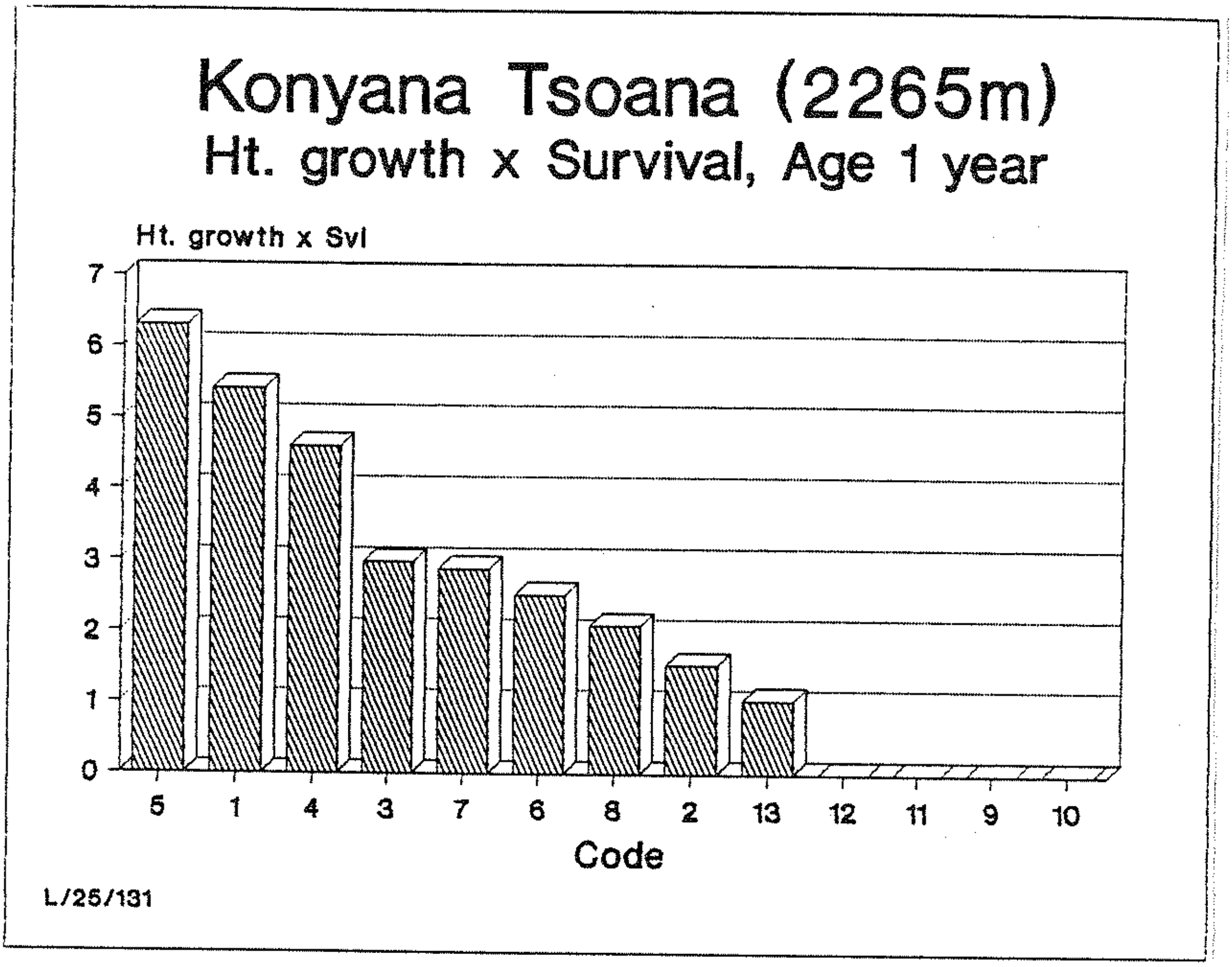

Table A3.1 Konyana Tsoana L/25/131 Age 1 year

Code	Species	Seedlot	Ht growth (m)	Survival	Ht growth x svl
1	P. ponderosa	PO85/030	0.057	95	5.42
2	P. ponderosa	OR943-1	0.021	73	1.53
3	P. ponderosa	OR863-1	0.035	85	2.98
4	P. ponderosa	0-142	0.05	92	4.60
5	P. ponderosa	NM-180	0.065	97	6.31
6	P. jeffreyi	2-37412	0.02	84	1.68
7	P. densiflora	PDK-1	0.043	67	2.88
8	P. thunbergii	PTK-1	0.029	72	2.09
9	P. radiata	PR87/1	0	0	0.00
10	P. radiata	25198	0	0	0.00
11	C. glabra		0	27	0.00
12	P. pinaster		0	0	0.00
13	F. pennsylvanica		0.013	80	1.04

Height Growth x Survival has been multiplied by 100

FIGURE A3.2

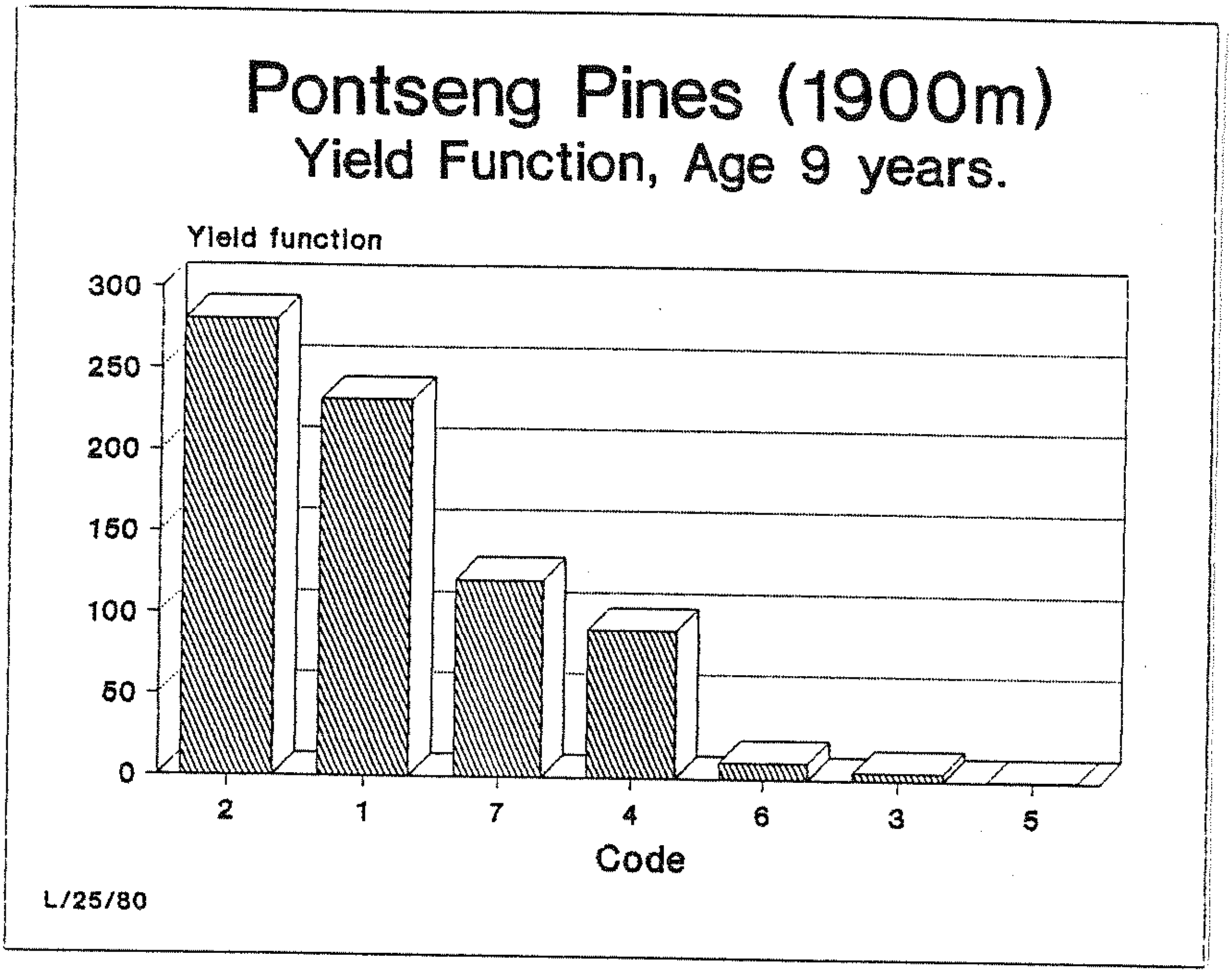

Table A3.2 Pontseng Pines L/25/80 Age 9 years

Code	Species	Seedlot	Height	dbh	Survival	Yield F.
1	P. patula	ex RSA	10.5	21	50	231.53
2	P. radiata	ex RSA	10.7	20.9	60	280.43
3	P. eldarica	PE-77-PK	3	5.5	50	4.54
4	P. roxburghii	ex RSA	5.7	12.6	100	90.49
5	P. ponderosa	ex El Dorado	0.95	1	33	0.03
6	P. pseudostrobus	R1003	4.4	6.8	50	10.17
7	P. muricata	R1004	8.9	16.5	50	121.15

FIGURE A3.3

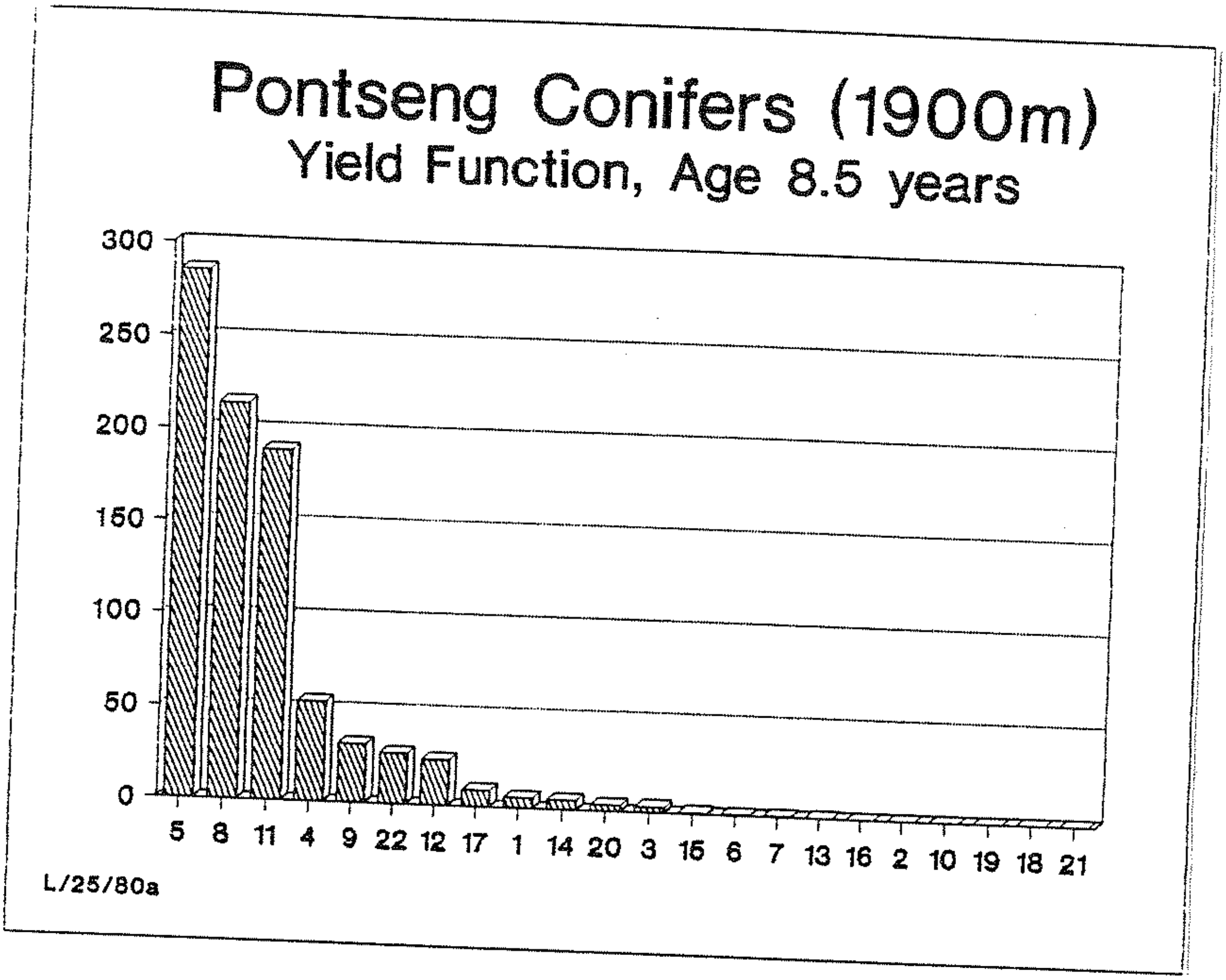

Table A3.3 Pontseng Conifer Species Trial L/25/80a, Age 8.5 years

Code	Species	Seedlot	Dbh	Height	Survival	Yield F.
1	P. brutia	594	5.3	3.6	58	5.87
2	P. brutia	PBC1	2.2	2	7	0.07
3	P. echinata	110-33	10.6	5.5	5	3.09
4	P. elliottii	28693	12.3	6.6	54	53.92
5	P. greggii	PGG1	18.2	9.9	87	285.30
6	P. halepensis	29278	5	2.8	7	0.49
7	P. halepensis	PHG1	4.5	2.4	8	0.39
8	P. montezumae	30598	19.7	8.9	62	214.15
9	P. muricata	PMC1	11.6	4.6	51	31.57
10	P. nigra	404	1	0.7	50	0.04
11	P. patula	R1008	18.3	11.3	50	189.21
12	P. taeda	28442	18.7	8.8	8	24.62
13	P. thunbergii	PTK1	4.8	2.9	4	0.27
14	P. virginiana	132-07	12.5	5.7	6	5.34
15	C. glabra	30524	5	4.2	7	0.73
16	C. semp horiz	CHSC1	2.6	3.4	4	0.09
17	C. semp horiz	26997	6	4.5	55	8.91
18	P. pseudostrobus	30/77	0	0	0	0.00
19	P. jeffreyi	1	1	0.6	33	0.02
20	P. pinaster	28558	8.7	8.4	5	3.18
21	P. strobiformis	PS-78-COC	0	0	0	0.00
22	P. sabiniana	Italy	6.6	6.3	100	27.44

FIGURE A3.4

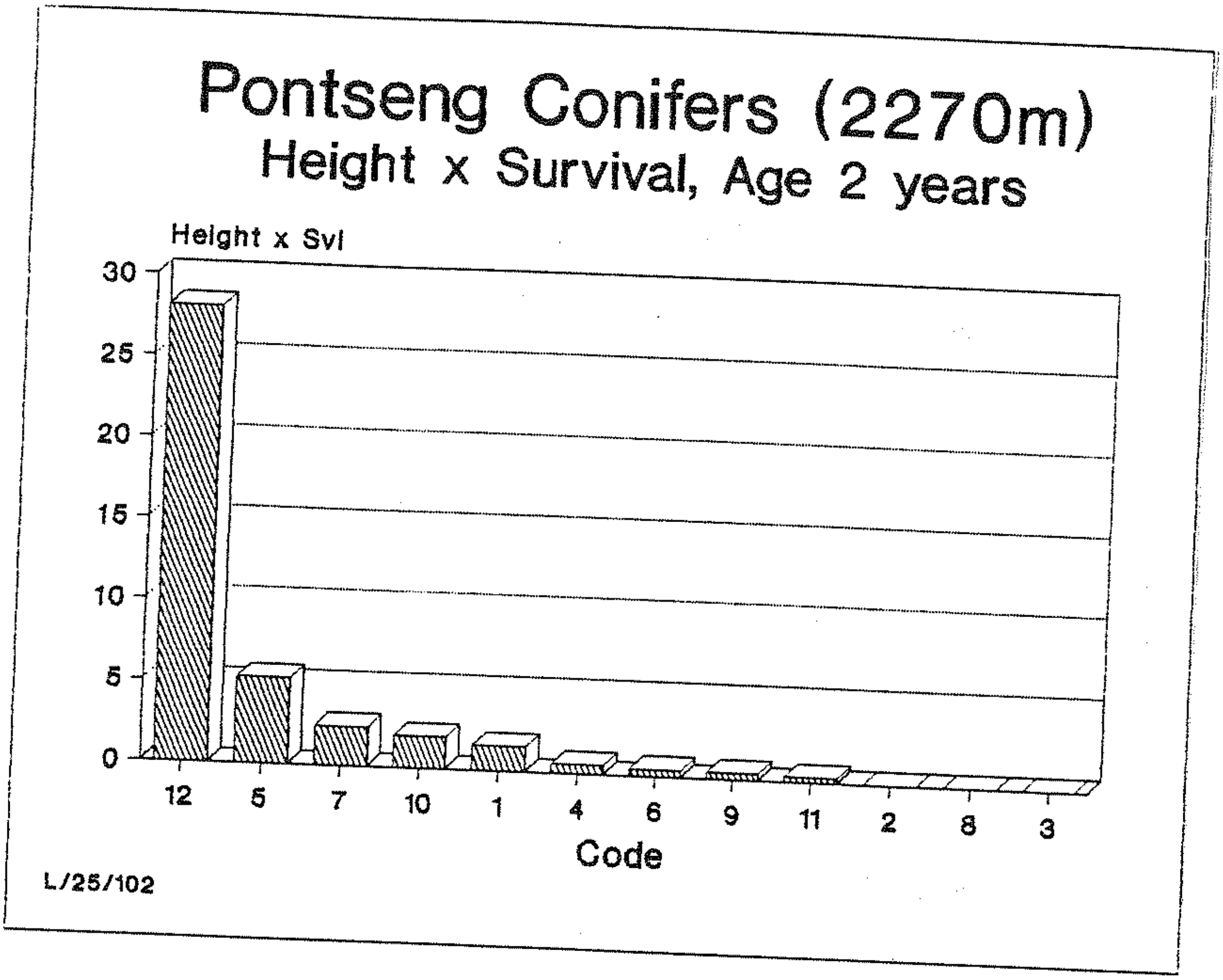

Table A3.4 Pontseng Conifers L/25/102 Age 2 years

Code	Species	Seedlot	Height	Survival	Ht x Svl
1	P. strobiformis	PS-78-COC	7.9	19.4	1.53
2	P. strobiformis	No 1	0	0	0.00
3	P. radiata	29925	0	0	0.00
4	P. patula	29810	20	2.8	0.56
5	P. ponderosa		10.6	50	5.30
6	P. eldarica	PE-77-PK	15	2.8	0.42
7	P. edulis	No 5	8.7	27.8	2.42
8	P. lambertiniana	No 9	0	0	0.00
9	P. jeffreyi	No 7	4.8	8.6	0.41
10	P. sabiniana	No 8	17.7	11.1	1.96
11	P. ponderosa	PP-78-COC	5.5	5.6	0.31
12	C. glabra	ex Arizona	37.5	75	28.13

P. ponderosa is variety scopulorum, no seedlot number

FIGURE A3.5

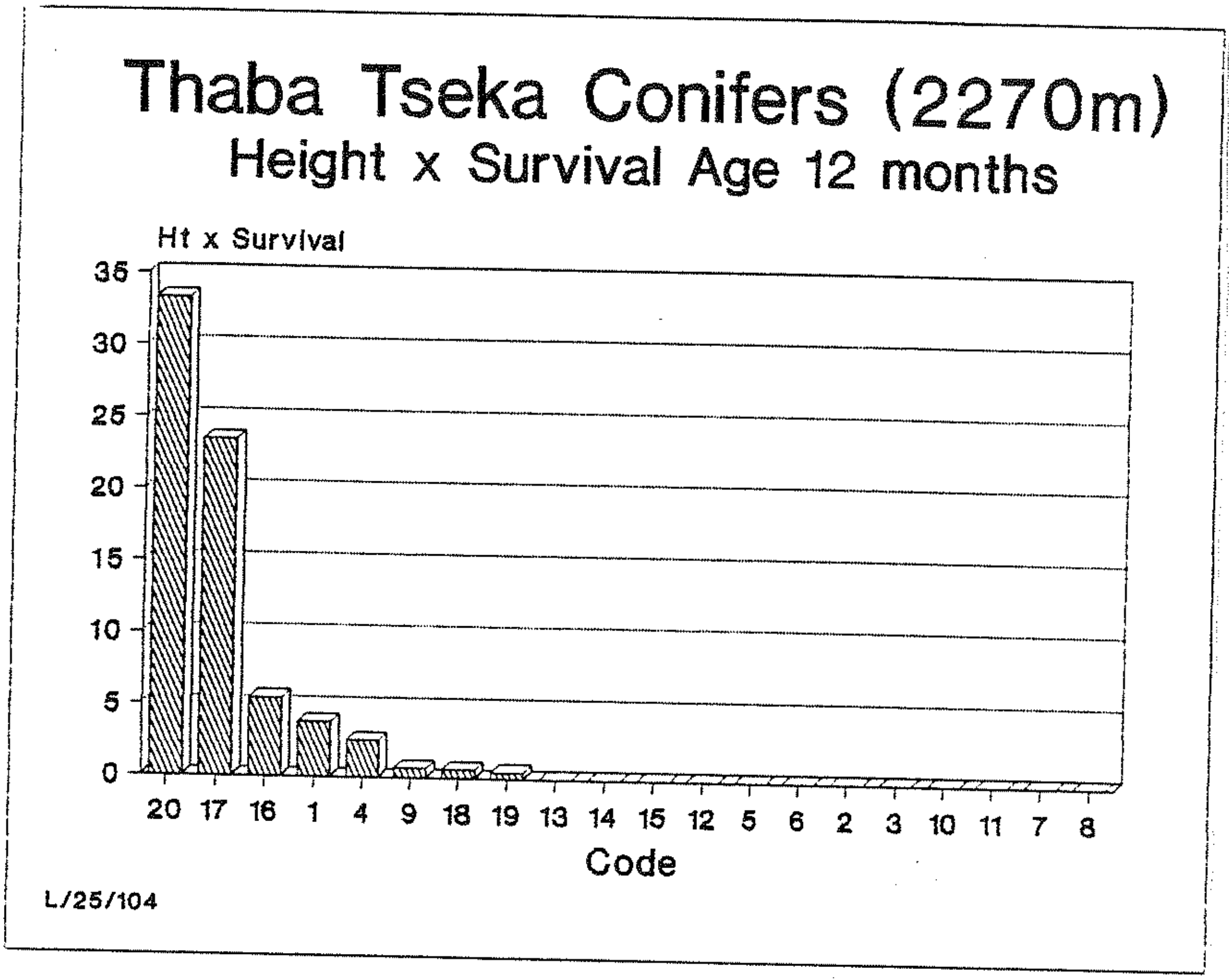

TABLE A3.5
Thaba Tseka Conifers L/25/104 Age 12 months

Code	Species	Seedlot	Height	Survival	Ht x Svl
1	P. brutia	594	12.8	30	3.84
2	P. brutia	PBC1	0	0	0.00
3	P. echinata	110-33	0	0	0.00
4	P. eldarica	PE-77-PK	17.3	15	2.60
5	P. greggii	PGG1	0	0	0.00
6	P. montezumae	30598	0	0	0.00
7	P. muricata	R1004	0	0	0.00
8	P. muricata	PMC1	0	0	0.00
9	P. nigra	404	13	5	0.65
10	P. patula	29810	0	0	0.00
11	P. patula	R1028	0	0	0.00
12	P. radiata	26209	0	0	0.00
13	P. radiata	30647	0	0	0.00
14	P. thunbergii	PTK1	0	0	0.00
15	P. virginiana	132-07	0	0	0.00
16	C. glabra	CGC1	18.2	30	5.46
17	C. glabra	30524	39.1	60	23.46
18	C. glabra	Lesotho	6	10	0.60
19	C. horiz	CSHC1	8.5	5	0.42
20	C. horiz	26997	39.2	85	33.32

Height in cm

Appendix 4

C. glabra
Land Race/ Provenance Trials

Results,
Analysis
&
Summary

Introduction

Three trials of *C. glabra* land race and provenance trials (L/25/90FA to L/25/90FC) were planned for 1984. The experiment at Thaba Tseka (L/25/90FB) does not seem to have been planted and that at Bushmans' Pass was closed early. Survival at this trial was very low because of browsing, fire and rat damage. The results of the remaining trial, at Libibing (L/25/90FC) are discussed in this appendix.

Results

Results are shown in Table A4.1 and graphically in Fig A4.1.

Discussion

An ANOVAR on the data from Libibing, showed no significant differences in height growth or survival. Examining the Height x Survival showed the Ladybrand seedlot to have best performance. This origin was recommended previously, (Richardson, 1986) and should continue to be used. The Ladybrand Plantations also have the advantage of being only 18km from Maseru, keeping travelling costs and time low. From the results of this trial there would appear to be no advantage in importing seedlots from areas other than Ladybrand.

FIGURE 4.1

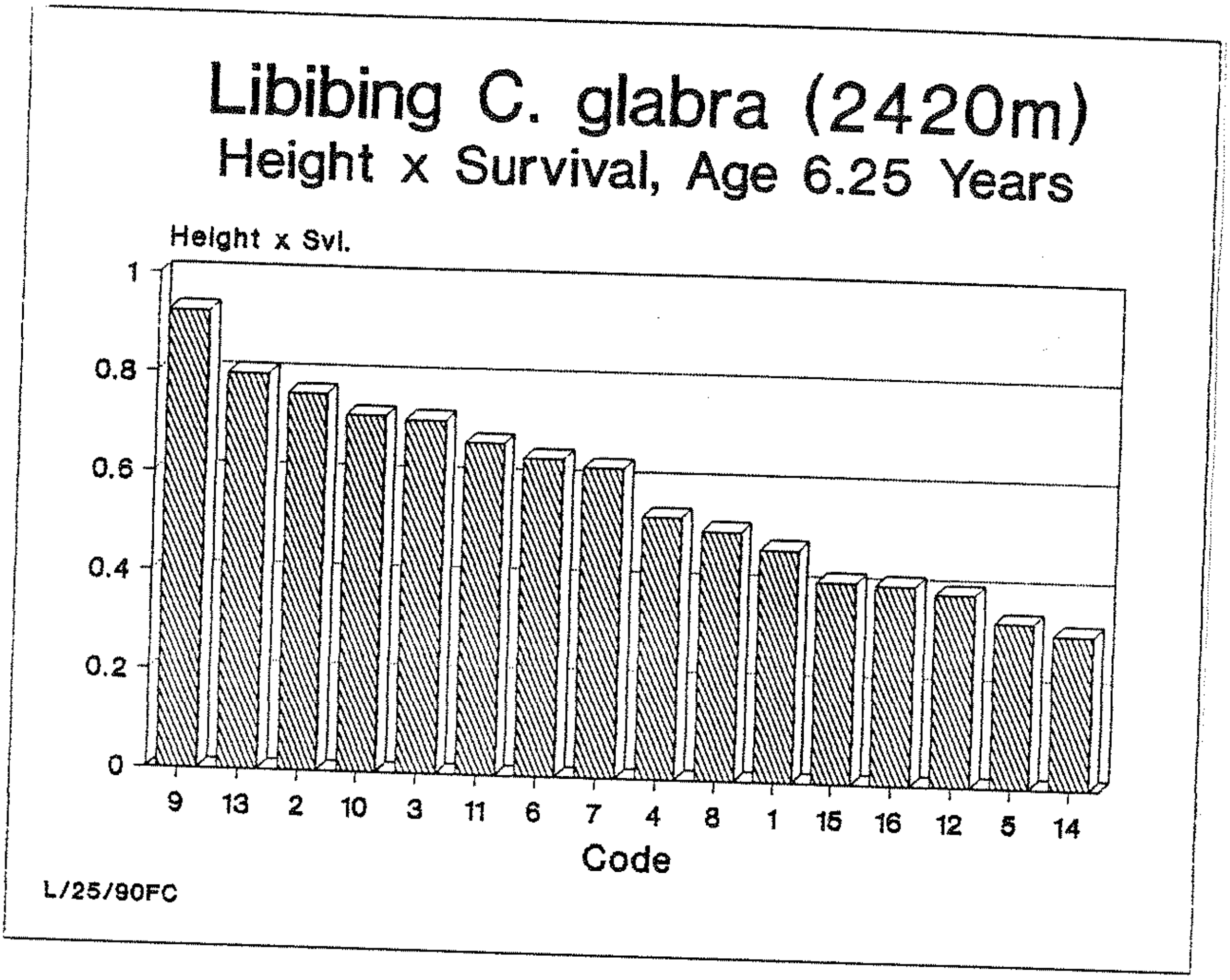

Table A4.1 Libibing C. glabra Provenance Trial L/25/90FC, Age 6.25 years

Code	Origin	Seedlot	Height	Survival	Ht x Survival
1	Mokhotlong	CGL1	1	47	0.47
2	Maseru	CGL2	1.19	64	0.76
3	Ha Ntoate	CGL3	0.83	86	0.71
4	Likaleneng	CGL4	1.06	50	0.53
5	Molimo Nthuse	CGL5	1.19	28	0.33
6	Khanyane	CGL7	1.31	49	0.64
7	Alwynskop	CGL8	1.06	59	0.63
8	Tweespruit	CGR1	1.05	48	0.50
9	Ladybrand	CGR2	1.32	70	0.92
10	Cyprus	CGC2	1.2	60	0.72
11	Syria	CGS1	1.34	50	0.67
12	N. Zealand	CGN1	1.11	35	0.39
13	Italy	SETROPA	1.23	65	0.80
14	Israel	ISRAEL1	0.89	35	0.31
15	Spain	SPAIN1	0.85	48	0.41
16	Arizona	051-11	0.94	43	0.40

TABLE A4.2 Analysis of Variance for HEIGHT

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	1.3420043	17	.0789414	1.119	.3837
BLOCK	.1607025	2	.0803513	1.139	.3341
CODE	1.1977875	15	.0798525	1.132	.3739
RESIDUAL	2.0462808	29	.0705614		
TOTAL (CORR.)	3.3882851	46			

1 missing values have been excluded.

TABLE A4.3 Analysis of Variance for LIBIBCG.TRANSURV

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	1.5215110	17	.0895006	1.467	.1770
LIBIBCG.CODE	1.4150667	15	.0943378	1.546	.1528
LIBIBCG.BLOCK	.1161161	2	.0580580	.952	.3979
RESIDUAL	1.7694051	29	.0610140		
TOTAL (CORR.)	3.2909161	46			

1 missing values have been excluded.

TABLE A4.4.

Multiple range analysis for LIBIBCG.SURVIVAL by LIBIBCG.CO

Method: 95 Percent Confidence Intervals

Level	Count	Average	Homogeneous Groups
5	3	28.333333	*
14	3	35.000000	**
12	3	35.333333	**
16	3	43.000000	**
1	3	46.666667	**
15	3	47.666667	**
8	3	48.000000	**
6	3	49.000000	**
4	3	49.666667	**
11	3	49.666667	**
7	3	58.666667	**
10	3	60.333333	**
2	3	64.000000	**
13	3	64.666667	**
9	3	69.666667	**

Appendix 5

Early P. radiata Land Race/ Provenance Trials

Results, Analysis & Summary

Introduction

Two types of *P. radiata* land race and provenance trials have been established in Lesotho. The early trials were established in 1984 at three sites; Tsereoane (L/25/115FA), Leshoboro (L/25/115FB) and Ha Ntsane (L/27/115FC). These tested South African and Lesotho land races. The second series, which is not reported on in this appendix tested seedlots from a wide variety of origins including New Zealand and the South Africa.

Results

Results are shown in Table A5.1, A5.6 and A5.10 and of the ANOVARS in Tables A5.2, A5., A5.4, A5.7, A5.8 and A5.9 and Yield Functions or Height x Survival are displayed in Figures A5.1 to A5.3. Height x Survival was used to rank the performance at Ha Ntsane because dbh was not measured in the latest assessment.

Discussion

The same nine seedlots were tested at all three sites:

1	PR83/1	Bela Bela, Lesotho
2	PR83/2	Mopeli, Lesotho
3	PR83/3	Thota Peli, Lesotho
4	PR83/4	Tale, Lesotho
5	PR83/5	Morija, Lesotho
6	PR83/6	Lesotho Agricultural College, Maseru
7	25142	Improved RSA
8	32886	RSA
9	32843	RSA

At Tsereoane there were significant differences (at the 5% level) for dbh, but not survival or height. When a multiple range test was applied to the data three groups were identified, with considerable overlap. The best performing group in terms of diameter growth comprised PR83/1, 32843, PR/83/5, PR83/6, PR83/3 and 25142. Examining the graph of Yield Function gave similar results.

These results contrast with those of Leshoboro Plateau. There were no significant differences at the 5% level, although at 10% there were significant differences between heights and dbhs. Ranking the seedlots by Yield Function, gave rather different results from those obtained at Tsereoane. The 32843 seedlot has again performed well, but the best was PR83/2, which did not produce good results at Tsereoane or at Ha Ntsane.

At Ha Ntsane two South African seedlots; 32886 and 25142 performed best in terms of Height x Survival. Other seedlots in the top five, ranked by Height x Survival were PR83/3, PR83/1 and PR83/5. Differences in height or survival were not significant at the 5% level.

Only one seedlot was in the top five at all trials, by Yield Function or Height x Survival, the PR83/1 from Bela Bela. However, at Tsereoane only was there statistically significant differences.

FIGURE A5.1

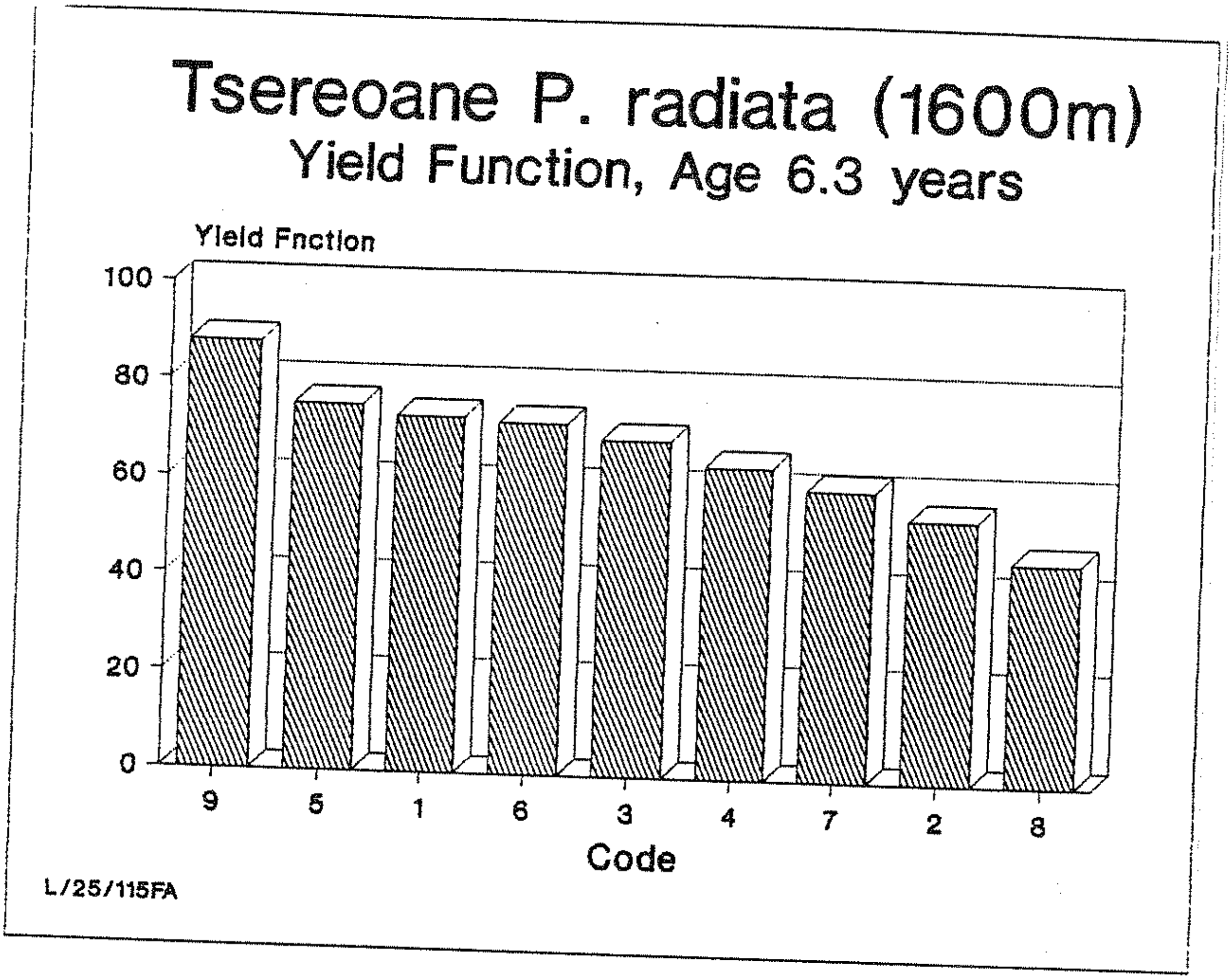

Table A5.1 Tsereoane Pinus radiata Provs. L/25/115FA Age 76

Code	Seedlot	Dbh	Height	Survival	Yield F
1	PR83/1	12.4	7.14	66.7	73.23
2	PR83/2	10.6	6.57	73.3	54.11
3	PR83/3	11.4	6.89	77.3	69.22
4	PR83/4	11	6.62	80	64.08
5	PR83/5	11.6	7.12	78.7	75.40
6	PR83/4	11.5	7.19	76	72.27
7	25142	11.2	6.17	77.3	59.83
8	32886	10.4	6.11	69.3	45.80
9	32843	12.2	7.14	82.7	87.89

TABLE A5.2 Analysis of Variance for TSEPIRAD.HEIGHT

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. leve
MAIN EFFECTS	5.0503704	10	.5050370	1.969	.1094
TSEPIRAD.BLOCK	.2496296	2	.1248148	.487	.6235
TSEPIRAD.CODE	4.8007407	8	.6000926	2.340	.0704
RESIDUAL	4.1037037	16	.2564815		
TOTAL (CORR.)	9.1540741	26			

0 missing values have been excluded.

TABLE A5.3 Analysis of Variance for TSEPIRAD.SURVIVAL

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	1322.6667	10	132.26667	.596	.7953
TSEPIRAD.CODE	650.6667	8	81.33333	.366	.9235
TSEPIRAD.BLOCK	672.0000	2	336.00000	1.514	.2500
RESIDUAL	3552.0000	16	222.00000		
TOTAL (CORR.)	4874.6667	26			

0 missing values have been excluded.

TABLE A5.4 Analysis of Variance for TSEPIRAD.DBH

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	28.379259	10	2.8379259	9.736	.0000
TSEPIRAD.CODE	10.169630	8	1.2712037	4.361	.0059
TSEPIRAD.BLOCK	18.209630	2	9.1048148	31.236	.0000
RESIDUAL	4.6637037	16	.2914815		
TOTAL (CORR.)	33.042963	26			

0 missing values have been excluded.

TABLE A5.5. Multiple range analysis for TSEPIRAD.DBH by TSEPIRAD.C

Method: 95 Percent Confidence Intervals

Level	Count	Average	Homogeneous Groups
8	3	10.433333	*
2	3	10.600000	*
4	3	11.033333	**
7	3	11.166667	***
3	3	11.366667	***
6	3	11.500000	***
5	3	11.600000	***
9	3	12.166667	**
1	3	12.400000	*

FIGURE A5.2

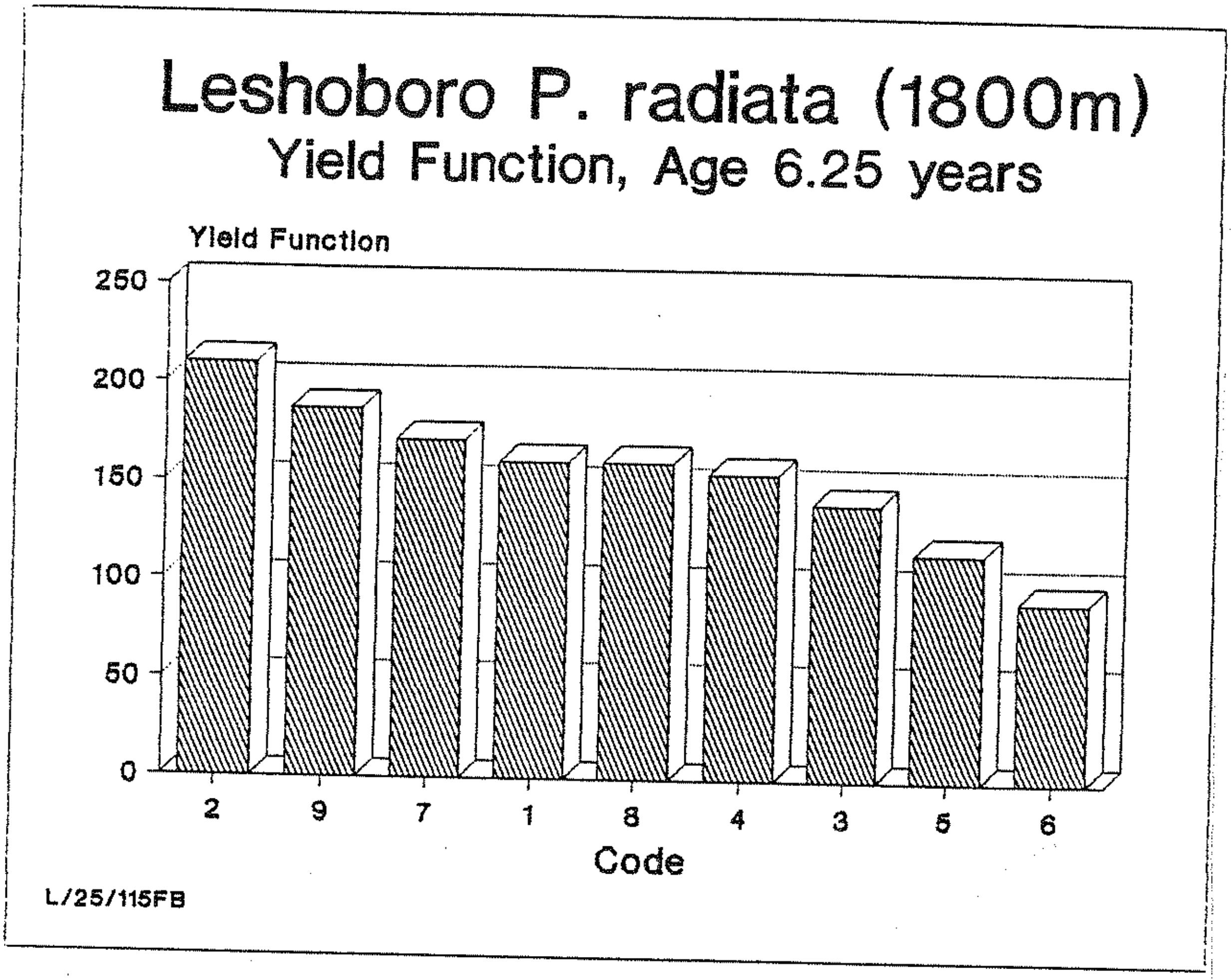

Table A56 Leshoboro Plateau P. radiata Provs. L/25/115FB Age 6.25 years

Code	Seedlot	Dbh	Height	Survival	Yield F.
1	PR83/1	13.99	8.62	95.37	160.90
2	PR83/2	14.39	10.43	97.22	209.97
3	PR83/3	13.05	8.48	97.22	140.40
4	PR83/4	13.7	8.59	96.29	155.24
5	PR83/5	12.37	7.91	95.37	115.43
6	PR83/6	11.79	7.32	89.95	91.53
7	25142	14.32	8.78	95.37	171.71
8	32886	14.29	8.5	92.59	160.71
9	32843	14.63	8.91	98.15	187.18

TABLE A5.7 Analysis of Variance for LESPIRAD.TRANSURV

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. leve
MAIN EFFECTS	.2583973	10	.0258397	1.052	.4475
LESPIRAD.CODE	.1976045	8	.0247006	1.006	.4689
LESPIRAD.BLOCK	.0607929	2	.0303964	1.238	.3164
RESIDUAL	.3929539	16	.0245596		
TOTAL (CORR.)	.6513512	26			

0 missing values have been excluded.

TABLE A5.8 Analysis of Variance for LESPIRAD.DBH

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	38.014815	10	3.8014815	1.676	.1721
LESPIRAD.CODE	25.416296	8	3.1770370	1.401	.2687
LESPIRAD.BLOCK	12.598519	2	6.2992593	2.778	.0921
RESIDUAL	36.281481	16	2.2675926		
TOTAL (CORR.)	74.296296	26			

0 missing values have been excluded.

TABLE A5.9 Analysis of Variance for LESPIRAD.HEIGHT

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	26.239889	10	2.6239889	2.321	.0644
LESPIRAD.CODE	11.864400	8	1.4830500	1.312	.3057
LESPIRAD.BLOCK	14.375489	2	7.1877444	6.357	.0093
RESIDUAL	18.091911	16	1.1307444		
TOTAL (CORR.)	44.331800	26			

0 missing values have been excluded.

FIGURE A53

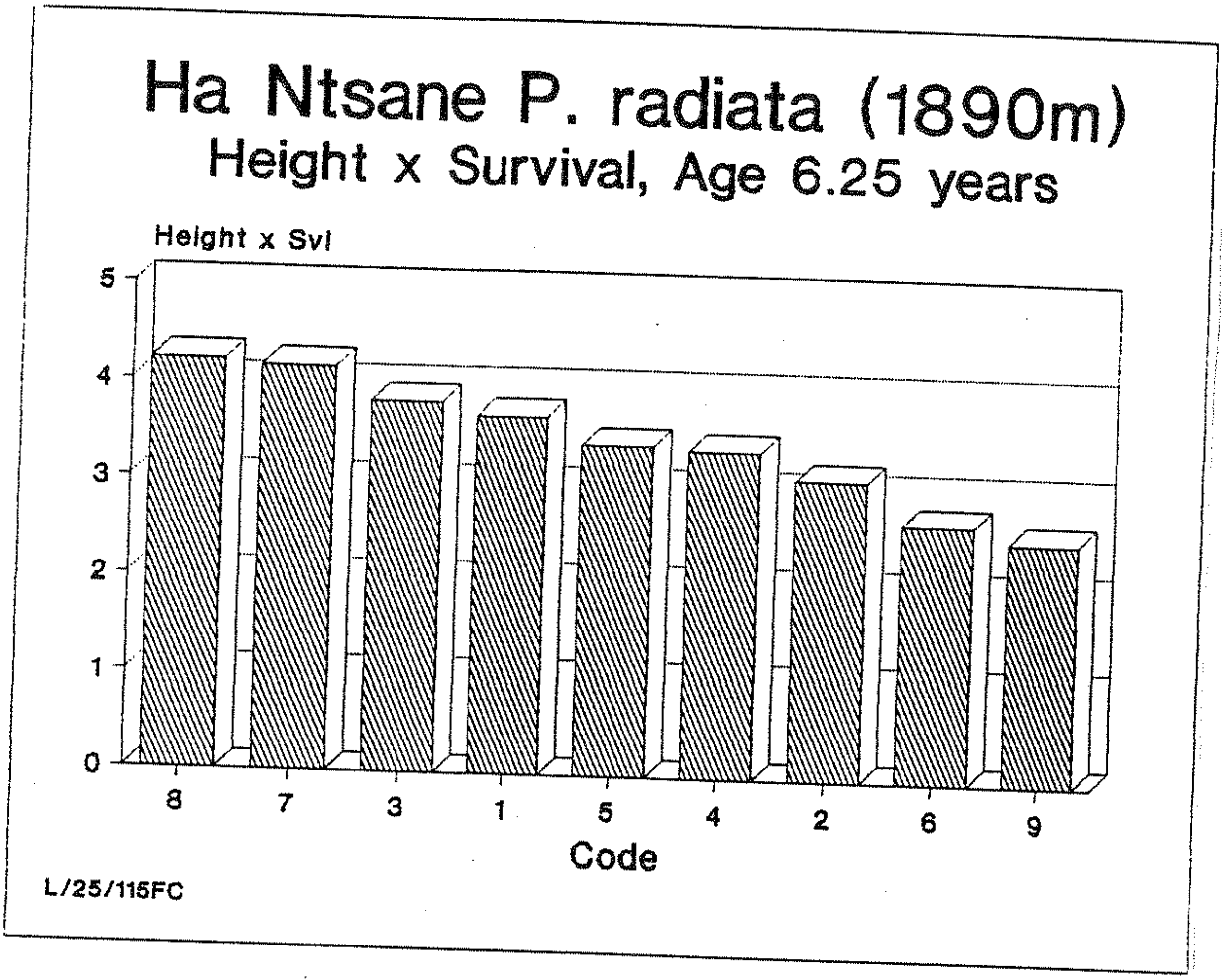

Table A5.10 Ha Ntsane P. radiata Provs. L25/115FC Age 6.25 years

Code	Seedlot	Height	Survival	HtxSvl
1	PR83/1	6.94	53.1	3.69
2	PR83/2	7.34	42.1	3.09
3	PR83/3	7.4	51.6	3.82
4	PR83/4	7.44	45.3	3.37
5	PR83/5	6.6	51.6	3.41
6	PR83/6	6.9	38.5	2.66
7	25142	7.2	57.8	4.16
8	32886	7.1	59.4	4.22
9	32843	6.4	39	2.50

TABLE A5.11 Analysis of Variance for HANYPIRA.HEIGHT

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	15.519766	11	1.4108878	.646	.7722
HANYPIRA.BLOCK	1.294211	3	.4314035	.198	.8970
HANYPIRA.CODE	14.442655	8	1.8053319	.827	.5873
RESIDUAL	52.385789	24	2.1827412		
TOTAL (CORR.)	67.905556	35			

0 missing values have been excluded.

TABLE A5.12 Analysis of Variance for HANYPIRA.SURVIVAL

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	22388.737	11	2035.3397	.847	.5986
HANYPIRA.BLOCK	6476.737	3	2158.9123	.899	.4563
HANYPIRA.CODE	16058.740	8	2007.3425	.835	.5808
RESIDUAL	57662.013	24	2402.5839		
TOTAL (CORR.)	80050.750	35			

0 missing values have been excluded.

Appendix 6

Late P. radiata
Land Race/ Provenance Trials

Results,
Analysis
&
Summary

Introduction

There are only preliminary results for the later *P. radiata* provenance/ land race trials. In these trials seedlots from New Zealand, USA and South Africa have been tested against Lesotho land races.

Results

Height x Survival, means for height, dbh and survival are listed in Tables A6.1, A6.8 and A6.9. Height x Survival is graphically displayed in Figures A6.1 to A6.3. As they are preliminary results an ANOVAR was only conducted on data from Ha Khorai, the oldest trial. Results of the ANOVAR are shown in Tables A6.3 to A6.5.

Discussion

Large block differences were apparent in the data from Ha Khoarai. This was because two blocks were established on pitted ground while the other was on ploughed ground. Height growth on the ploughed ground was 3 to 4 times that of the pitted ground. Competition from weed growth was severe on the pitted site, whereas the plough lines were almost free of weeds.

From these preliminary results there would appear to be no obviously superior seedlot for the type of sites these three trials represent.

At Ha Khoarai, in the foothills, a multiple range test divided the seedlots into five groups with considerable overlap between all groups. Examining Height x Survival (Figure A6.1) showed one of the Lesotho seedlots, PR87/3, from Thota Peli to be the worst performer. The other Lesotho seedlot, PR87/1, from Bela Bela had shown good growth and survival.

Growth generally was poor at Ha Mokhatla, which can be largely attributed to the duplex soils of the site. Waterlogging during the rainy season occurs over much of the area and the foliage of the *P. radiata* showed chlorosis.

Molumong is located on a plateau top and unfortunately the fence had been cut and considerable damage from browsing had occurred.

FIGURE A6.1

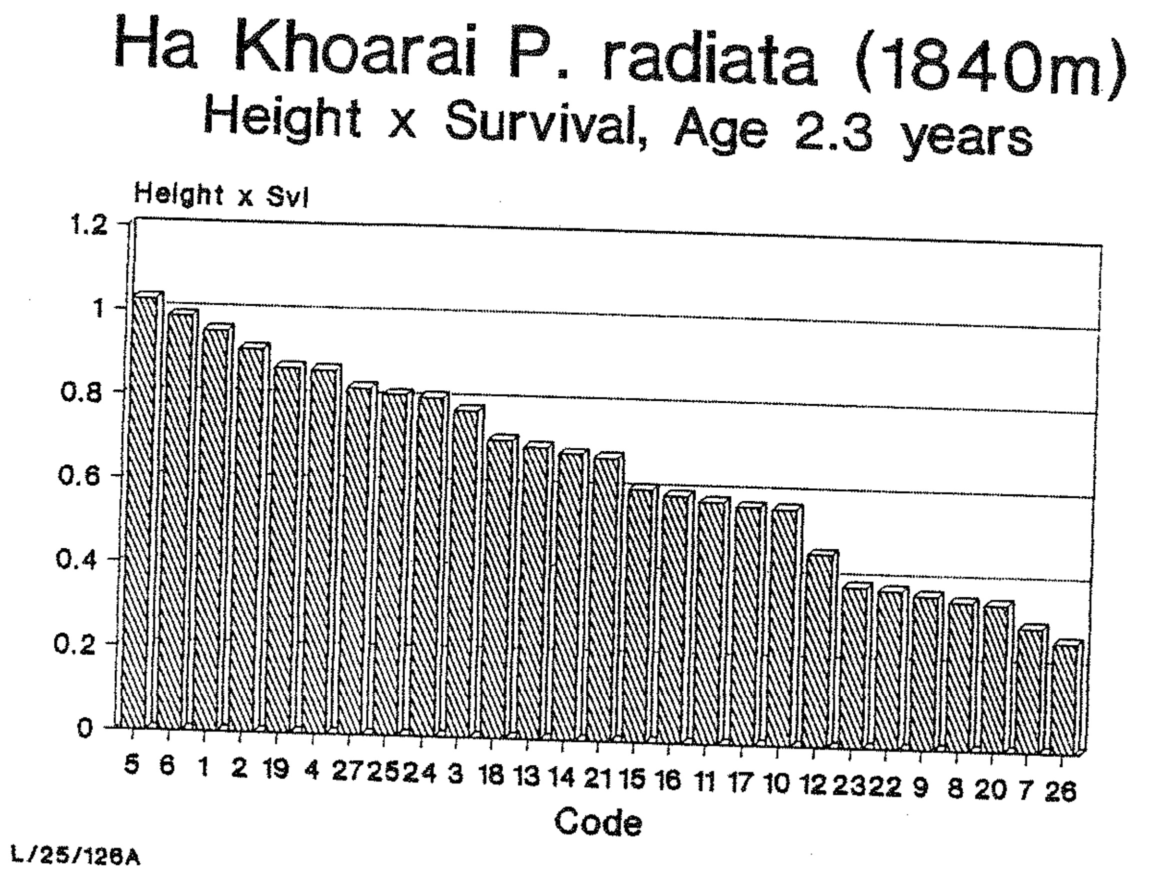

Table A6.1 Ha Khoarai P. radiata Provs. L/25/126A Age 2.3 years

Code	Seedlot	Height	Survival	Ht x Svl
1	12585	1.1	86.7	0.95
2	12586	1.05	86.7	0.91
3	12587	0.97	80	0.78
4	12588	1.18	73.3	0.86
5	12589	1.06	96.7	1.03
6	12590	1.02	96.7	0.99
7	PX6001	1.1	26.7	0.29
8	124-01	0.81	43.3	0.35
9	5-470B6	0.84	43.3	0.36
10	25181	0.84	66.7	0.56
11	12597	1.23	46.7	0.57
12	12596	1.14	40	0.46
13	12595	0.99	70	0.69
14	12594	0.97	70	0.68
15	12593	1.5	40	0.60
16	12592	0.88	66.7	0.59
17	12591	0.99	57	0.56
18	124-03	1.06	66.7	0.71
19	25155	1.24	70	0.87
20	1/0/77/13/3	1.04	33.3	0.35
21	2/1/84/51/2	1.26	53.3	0.67
22	2/2/84/67/3	1.02	36.7	0.37
23	3/3/82/002/3	1.04	36.7	0.38
24	7/1/77/01/3	1.61	50	0.81
25	6/1/79/27/2	1.52	53.3	0.81
26	PR87/3	1.3	20	0.26
27	PR87/1	0.99	83.3	0.82

TABLE A6.2 Multiple range analysis for HAKHPIRA.HTXSURV by HAKHPIRA.C

Method: 95 Percent Confidence Intervals

Level	Count	Average	Homogeneous Groups
10	3	.1770000	*
26	3	.3133333	**
12	3	.6033333	**
7	3	.6083333	**
13	3	.6410000	**
15	3	.6763333	**
8	2	.7190000	***
17	3	.7426667	****
16	3	.7513333	****
11	3	.7553333	****
3	3	.8153333	*****
24	3	.8286667	*****
27	3	.8413333	*****
14	3	.8440000	*****
18	3	.8446667	*****
20	2	.8525000	*****
22	2	.8690000	*****
6	3	.9603333	*****
9	2	.9645000	*****
1	3	.9740000	*****
25	3	.9803333	*****
2	3	.9853333	*****
5	3	1.0000000	*****
19	3	1.0020000	*****
4	3	1.0090000	*****
23	2	1.1860000	****
21	3	1.6576667	* *

TABLE A6.3 Analysis of Variance for HAKHPIRA.HEIGHT

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. leve
MAIN EFFECTS	31.819421	28	1.136408	12.311	.0000
HAKHPIRA.CODE	4.775283	26	.183665	1.990	.0198
HAKHPIRA.BLOCK	26.494314	2	13.247157	143.514	.0000
RESIDUAL	4.3383529	47	.0923054		
TOTAL (CORR.)	36.157774	75			

5 missing values have been excluded.

TABLE A6.4 Analysis of Variance for HAKHPIRA.SURVIVAL

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	47324.402	28	1690.1572	2.641	.0016
HAKHPIRA.CODE	30084.764	26	1157.1063	1.808	.0382
HAKHPIRA.BLOCK	18453.788	2	9226.8939	14.417	.0000
RESIDUAL	30079.545	47	639.99033		
TOTAL (CORR.)	77403.947	75			

5 missing values have been excluded.

TABLE A6.5 Analysis of Variance for HAKHPIRA.HTXSURV

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	35.029362	28	1.251049	8.440	.0000
HAKHPIRA.CODE	5.594566	26	.215176	1.452	.1313
HAKHPIRA.BLOCK	29.511185	2	14.755592	99.541	.0000
RESIDUAL	6.9670823	47	.1482358		
TOTAL (CORR.)	41.996445	75			

5 missing values have been excluded.

TABLE A6.6 Multiple range analysis for HAKHPIRA.HEIGHT by HAKHPIRA.C

Method: 95 Percent Confidence Intervals

Level	Count	Average	Homogeneous Groups
16	3	.8633333	*
10	3	.8700000	*
3	3	.9666667	**
14	3	.9700000	**
27	3	.9866667	**
13	3	.9900000	**
17	3	.9900000	**
6	3	1.0233333	**
2	3	1.0533333	**
18	3	1.0600000	**
5	3	1.0633333	**
7	3	1.1000000	**
1	3	1.1033333	**
12	3	1.1433333	**
4	3	1.1800000	**
8	2	1.2100000	***
11	3	1.2300000	****
19	3	1.2366667	****
9	2	1.2550000	*****
26	3	1.3000000	*****
15	3	1.5033333	*****
25	3	1.5166667	*****
22	2	1.5250000	*****
23	2	1.5550000	*****
20	2	1.5650000	*****
24	3	1.6066667	****
21	3	1.9633333	* *

TABLE A6.7 Multiple range analysis for HAKHPIRA.SURVIVAL by HAKHPIRA.C

Method: 95 Percent Confidence Intervals

Level	Count	Average	Homogeneous Groups
26	3	20.000000	*
7	3	36.666667	**
10	3	36.666667	**
12	3	40.000000	***
15	3	40.000000	***
11	3	46.666667	***
20	2	50.000000	***
24	3	50.000000	***
25	3	53.333333	***
22	2	55.000000	***
23	2	55.000000	***
17	3	56.666667	***
8	2	65.000000	***
9	2	65.000000	***
16	3	66.666667	***
18	3	66.666667	***
13	3	70.000000	***
14	3	70.000000	***
19	3	70.000000	***
4	3	73.333333	***
21	3	76.666667	***
3	3	80.000000	**
27	3	83.333333	**
1	3	86.666667	**
2	3	86.666667	**
5	3	96.666667	*
6	3	96.666667	*

FIGURE A6.2

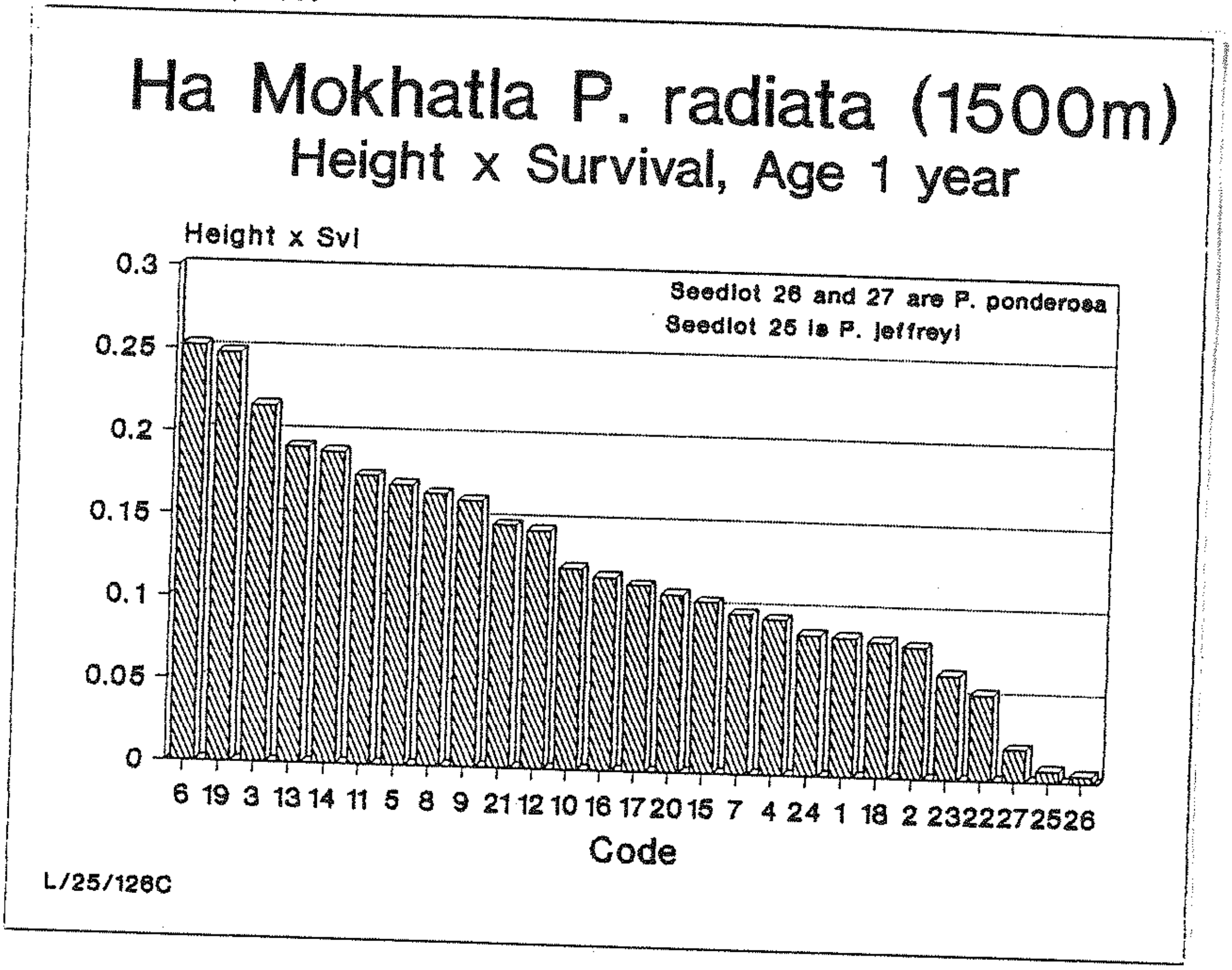

Table A6.8 Ha Mokhatla P. radiata Provs. L/25/126C, Age 1 year.

Code	Seedlot	Height	Survival	Ht x Svl
1	12585	0.4	21	0.08
2	12586	0.44	18	0.08
3	12587	0.54	40	0.22
4	12588	0.47	20	0.09
5	12589	0.5	34	0.17
6	12590	0.56	45	0.25
7	12591	0.46	21	0.10
8	12592	0.5	33	0.17
9	12595	0.52	31	0.16
10	12596	0.58	21	0.12
11	12597	0.53	33	0.17
12	123-03	0.45	32	0.14
13	PX6001	0.58	33	0.19
14	5-47068	0.54	35	0.19
15	1/0/77/13/3	0.45	23	0.10
16	2/1/84/51/2	0.45	26	0.12
17	2/2/84/67/3	0.45	25	0.11
18	3/3/82/002/3	0.39	21	0.08
19	7/1/77/01/3	0.59	42	0.25
20	6/1/79/027/2	0.43	25	0.11
21	25155	0.49	30	0.15
22	25160	0.47	11	0.05
23	25181	0.37	17	0.06
24	PR87/1	0.37	23	0.09
25	2-37412	0.11	6	0.01
26	0-142	0.08	5	0.00
27	NM180	0.16	12	0.02

Seedlot 25 is P. jeffreyi
Seedlot 26 and 27 are P. ponderosa

FIGURE A6.3

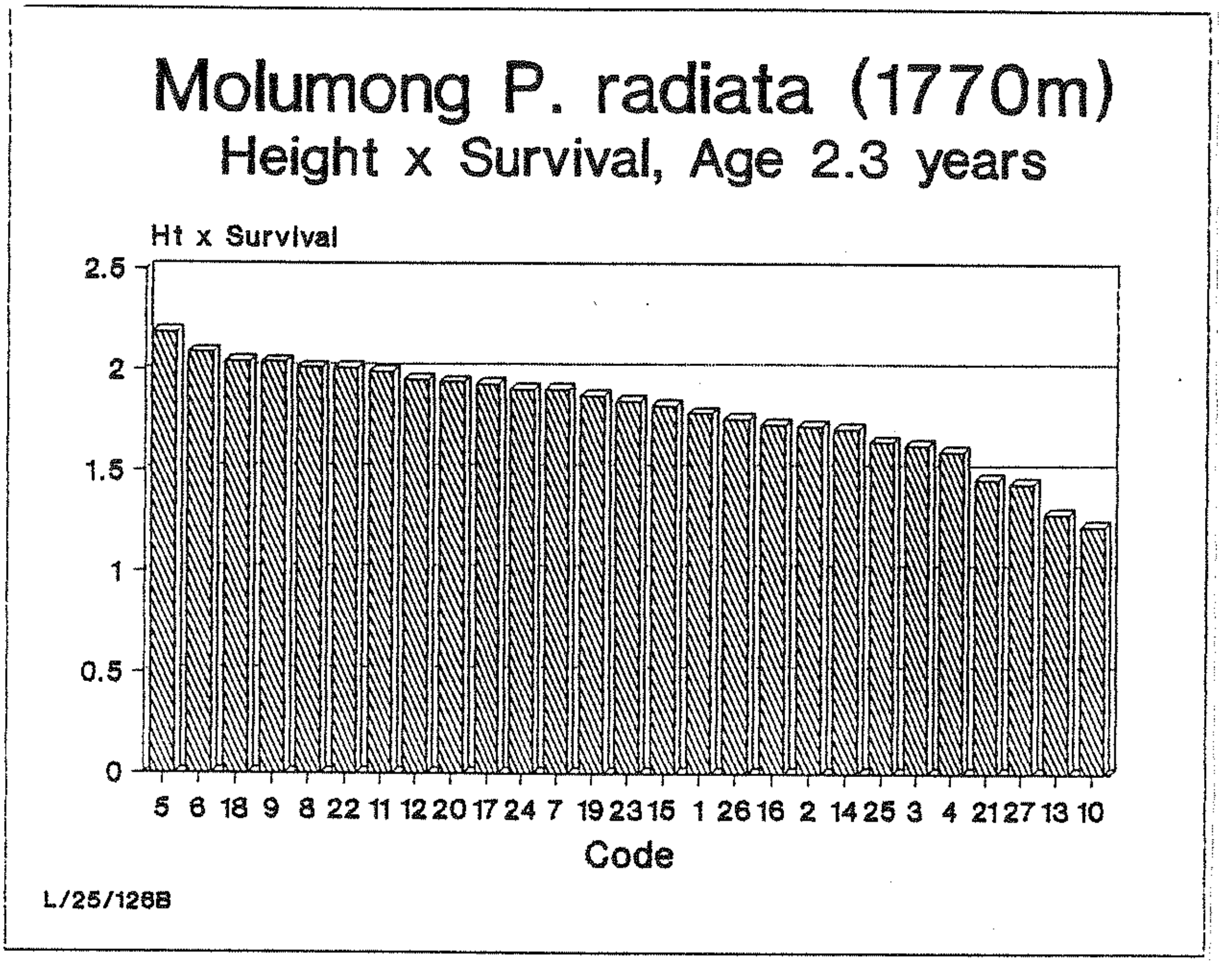

Table A69 Molumong P. radiata Provs L/25/126B Age 2.3 years

Code	Seedlot	Height	Survival	Ht x Svl
1	12585	1.84	97	1.78
2	12586	1.85	93	1.72
3	12587	1.75	93	1.63
4	12588	1.68	95	1.60
5	12589	2.23	98	2.19
6	12590	2.15	97	2.09
7	Px6001	1.96	97	1.90
8	124-1	2.01	100	2.01
9	5-47086	2.1	97	2.04
10	25181	1.29	95	1.23
11	12597	1.99	100	1.99
12	12596	2.01	97	1.95
13	12595	1.61	80	1.29
14	12594	1.76	97	1.71
15	12593	1.92	95	1.82
16	12592	1.86	93	1.73
17	12591	1.99	97	1.93
18	124-03	2.04	100	2.04
19	25155	1.97	95	1.87
20	1/0/77/13/3	2	97	1.94
21	2/1/84/51/2	1.78	82	1.46
22	2/2/84/67/3	2.05	98	2.01
23	3/3/82/002/3	1.94	95	1.84
24	7/1/77/01/3	1.94	98	1.90
25	6/1/79/027/2	1.73	95	1.64
26	25160	1.89	93	1.76
27	PR87/1	1.44	100	1.44